ORIGINAL SCIENTIFIC WORKS | LUCRĂRI ORIGINALE

PLASTINATION – A SCIENTIFIC METHOD OF RESEARCH IN ANATOMICAL FIELD*)

PLASTINAREA – METODĂ ŞTIINŢIFICĂ DE CERCETARE ÎN DOMENIUL ANATOMIEI

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ABSTRACT | REZUMAT

Plastination is a process of preservation of anatomical specimens through forced impregnation with curable polymers like silicone, epoxy or polyester resins, with vast applications in medicine. In this process, water and lipids in biological tissues are replaced by polymers (silicone, epoxy, polyester) which are hardened, resulting in dry, odorless and durable specimens. Nowadays, after more than 30 years of its development, plastination is applied in more than 400 departments of anatomy, pathology, forensic sciences and biology all over the world. The standard S10 silicone technique produces flexible, resilient and opaque specimens. After fixation and dehydration, the specimens are impregnated with silicone S10 and in the end the specimens are stiffened. The key element in plastination is the impregnation stage and therefore depending on the polymer that is used, the optical quality of the specimens differs. The S10 silicone technique is the most common technique used in plastination. It is used worldwide for beginners, but also for experimented plastinators. The S10 plastinated specimens can be easily stored at room temperature, are non-toxic and odorless. The S10 specimens can be successfully used, especially in teaching, as they are easy to handle and display a realistic topography. Plastinated specimens are also used for displaying whole bodies, or body parts in the exhibition. Transparent sections with a thickness between 1 and 4 mm can be produced with the help of plastination. These sections can be used to study and analyze both macroscopic and microscopic structures. Compared to the usual methods of dissection or corrosion, plastination has the advantage of not destroying or altering the connections of the connective tissue structures or cellular structures. Plastinated specimens can be used for morphometric studies as well as for three-dimensional reconstructions.

Keywords: anatomy, research, plastination, methods, history

Plastinarea este un proces de conservare a pieselor anatomice, cu aplicații enorme în domeniul ştiinţelor medicale, printr-o metodă de impregnare forțată cu polimeri curabili, precum rășini siliconice, epoxidice sau poliesterice. În acest proces, apa și lipidele din țesuturile biologice sunt înlocuite cu polimeri (silicon, epoxi, poliester) care sunt în final întăriți. In urma acestui proces obţinem piese plastinate uscate, inodore și durabile.

Astăzi, după mai bine de 30 de ani de dezvoltare, plastinarea se aplică în mai mult de 400 de departamente de anatomie, patologie, ştiințe criminalistice și biologie, din întreaga lume.

Tehnica de siliconizare standard S10 produce piese anatomice flexibile, rezistente și opace. După fixare și deshidratare, eșantioanele sunt impregnate cu silicon S10 și, în cele din urmă, specimenele sunt întărite.

Elementul cheie în plastinare este etapa de impregnare și, prin urmare, în funcție de polimerul utilizat, calitatea optică a eșantioanelor este diferită.

Tehnica de silicon S10 este cea mai frecventă tehnică utilizată în plastinare. Această tehnică este folosită la nivel mondial pentru începători, dar și pentru plastinatori experimentați. Piesele plastinate cu S10 pot fi ușor depozitate la temperatura camerei, sunt netoxice și inodore.

Piesele plastinate S10 pot fi utilizate cu succes, în special în predare, deoarece acestea sunt ușor de manevrat și prezintă o topografie realistă. Probele plastinate sunt folosite și pentru expunerea integrală sau a părților corpului - în expoziții.

Cu ajutorul plastinării se pot produce secţiuni transparente având o grosime cuprinsă între 1-4 mm. Aceste secţiuni pot fi folosite pentru a studia şi analiza atât structurile macro- cât şi cele microscopice.

In comparaţie cu metodele obişnuite de disecţie sau coroziune, plastinarea are avantajul că nu se distruge şi nu alterează raporturile structurilor ţesutului conjunctiv sau structurile celulare.

Secţiunile plastinate pot fi folosite pentru studii morfometrice dar şi pentru reconstrucţii tridimensionale.

Cuvinte cheie: anatomie, cercetare, plastinare, metode, istorie

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*) ***In memory and remembrance of Vasile COŢOFAN, Prof. DVM PhD, Dr.h.c. from Faculty of Veterinary Medicine of Iaşi, Romania***

INTRODUCTION

Plastination is a method of preserving organic tissue commonly used in anatomy to produce durable anatomical specimens of the entire body or body parts. At the beginning of the plastination process, the tissue fluid is substituted with acetone, and in turn it is substituted at a later stage by a polymer (Biodur) [7].

Invented by Gunter von Hagens 40 years ago, the method of plastination has gradually developed to serve both didactics and research.

The best known plastination technique is silicone polymer impregnation (Biodur S10) for the production of whole body parts or organ preservation (DeJong and Henry 2007; Raoof et al., 2007), followed by the epoxy polymer impregnation technique (Biodur E12) for the production of transparent tissue sections [37, 38, 41] and the polyester polymer impregnation technique (Biodur P40) for obtaining the encephalic sections [Sora 1998, Weber et al., 2007; Latorre, Henry 2007, Sui and Henry 2007] (Fig. 5).

Plastinated sections can be used as models for accurate drawing, can be digitally photographed or scanned to be stored indefinitely [10].

By evaluating the usage of the plastination process worldwide, we can distinguish three directions of development:

"**Commercial plastination**" - this category uses plastination to obtain plastinated parts for public exhibitions or for sale.

The trade with human corpses or plastinated organs is vehemently criticized by religious organizations, ethics committees, or lawyers.

"**Didactic plastination**" - deals with the production of plastinated specimens for didactic purposes in university institutions, biology or human and veterinary anatomy disciplines, or museums. The correlation of plastinated specimens is beneficial for the understanding of radiographic techniques such as echography, computed tomography or magnetic resonance tomography [7, 8, 9, 23, 25, 42].

"**Scientific plastination**" is dedicated to the production of plastinated specimens, especially of transparent tissue sections (E12 technique), which are used to process research topics, both on macroscopic and microscopic structures. Besides investigating macro and microscopic structures, plastination offers a great opportunity to investigate the intermediate structures of these areas, structures located in the "mesoscopic" area [38].

Currently, plastination is positioned as the most appropriate method for investigating structures in the mesoscopic area [4, 11, 12, 29, 30]. To investigate the organ cavities prior to plastination, these cavities may be injected with Biodur polymer, and then by the method of plastination to investigate the topographical ratios [5, 11, 12, 15, 16]. The pieces obtained by scientific plastination can also be used within various disciplines such as anatomy, histology and embryology for didactic purposes [25, 26].

Another alternative to the use and application of the scientific plastination is the three-dimensional reconstruction (3D) and the use of plastination for morphometric investigations. One of the great advantages of plastination is that by applying this method the local and regional topography is not disturbed, as is the case for dissection method.

The veterinary medicine uses for plastination sacrificed or euthanized animal parts, but the human medicine usually uses anatomical parts that are preserved by fixing with different chemical agents. The most used plastination technique is currently the one that uses Biodur S10 silicone polymer. This method can preserve whole human bodies, limbs or organs, but also human or animal body sections.

After plastination, the obtained anatomical parts comprise several advantageous characteristics: they are odorless, non-toxic and can be kept at room temperature for a long time. Another great advantage is that the plastinated anatomical parts do not contain formalin, and there is no need for protective measures against carcinogens.

MATERIAL AND METHODS

For the current study, there were used plastinated sections from two horse heads, produced using the Biodur S10 protocol (De Jong and Henry 2007; Latorre et al., 2007; Raoof et al., 2007).

At the same time, 5 mm thick sections of a horse's brain were selected and used, plastinated using the P40 method (Latorre and Henry 2007). For the transparent 1mm thick plastinated sections, made by using the Biodur E12 method, we used the distal side of a horse foreleg. The foreleg was previously injected vascularly with red Biodur E50 polymer. The E12 plastination technique was used for the production of ultra-thin sections [37, 38] in order to highlight the pathology of hoofthin structures affected by laminitis. With this technique, even human anatomical parts that contain endoprostheses or metallic implants can be easily processed. (Fig. 6)

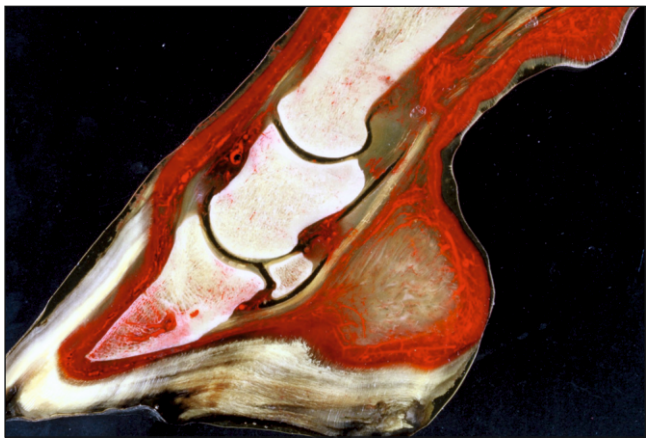

Fig. 1. Section E12 through the distal extremity of a left horse foreleg injected. Bone structures, tendons, cartilage, synovial membrane, and blood vessels are visible.

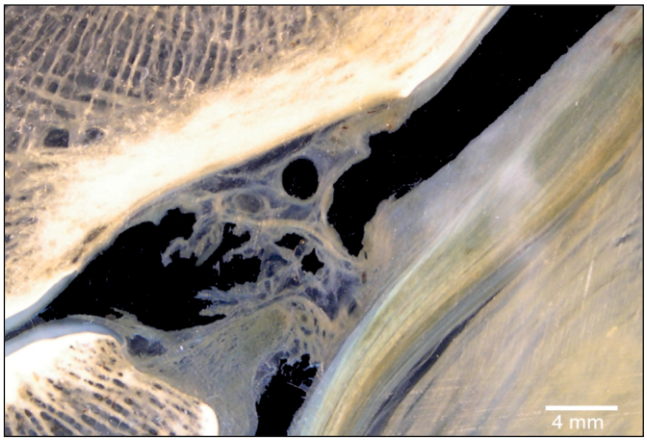

Fig. 2. Section E12 at the level of the podotroclear bursa of the digital horse organ. Fine bone structures, articular cartilage, and synovial villi are visible.

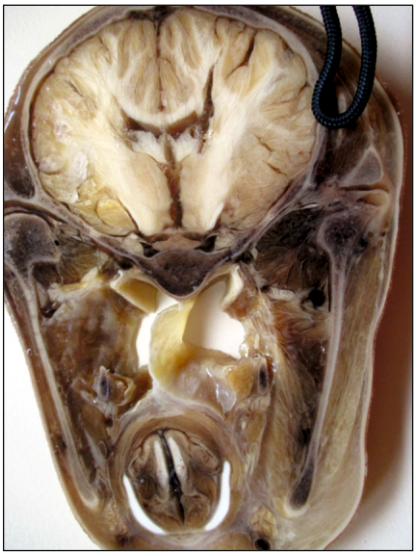

Fig. 3. Section S10 at the level of horse guttural pouch. Encephalon, cranial nerves around guttural pouches, intermediate wall and laryngeal structures are visible.

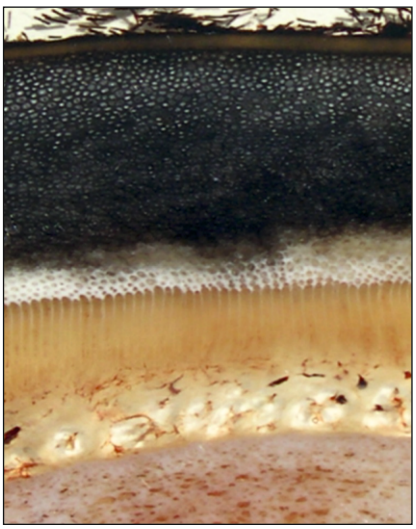

Fig. 4. Section E12 through the wall of a horse hoof. The callous layers, the keratogenic membrane and the distal phalanx are visible.

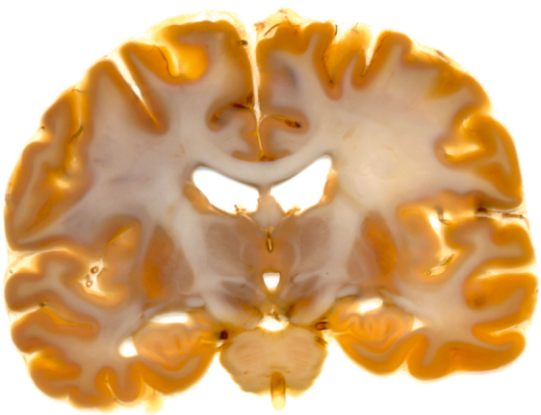

Fig. 5. P40 coronary section through human encephalon. Gray and white substance, lateral ventricles and the encephalic trunk are present.

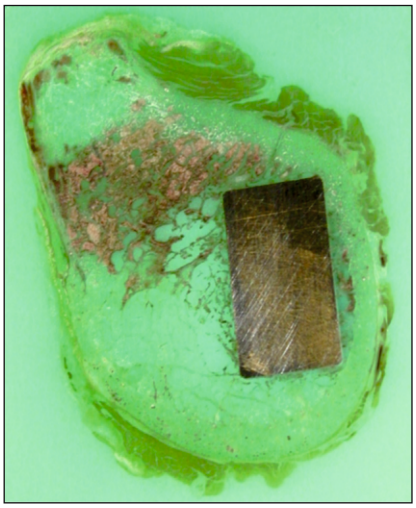

Fig. 6. Endoprothesis at the proximal extremity of the human femur. Section E12.

RESULTS

On the sagittal sections of the distal horse extremities, the bones can easily be noticed as well as the thin bone structure, tendons, ligaments, articular cartilage, synovial cavities and synovial vilosities. These structures can be investigated morphometrically and can be measured (Fig. 1 and 2).

On horse head sections we can investigate bones, laryngeal cartilage, components of the encephalon, temporomandibular joint, cranial nerves and structures around the guttural pouch. Encephalic sections have a distinct differentiation between white and gray, large encephalic nuclei, choroid plexuses and ventricular cavities can be easily identified (Fig. 3).

On the sections of the digital organ (hoof) of the horse we can see the primary podophile lamellae and the secondary lamellae, the dermal papillae and the callous layers of the hoof (Fig. 4).

On the injected plastinated parts it is easy to notice the vascular tract, as well as the special conjunction of the arteries and veins inside the digital organ, especially in the palmar arch of the distal phalanges. Inside this arch the artery is accompanied by two veins so that it can fulfill the function of a permanent pump. Arterial pulse pushes venous blood towards the proximal end of the extremity in the direction of the heart.

DISCUSSIONS AND CONCLUSIONS

In anatomy, plastination is currently the most effective method when describing topographical regions [7, 22] or for measurements or to produce 3D reconstructions [37]. The three-dimensional reconstruction of anatomical structures uses plastinated sections with a thickness of 0.3 - 0.5 mm. These reconstructions can be used for biomechanical investigations as well as for morphometric measurements.

The use of the plastination method for clinical purposes in horses leads to the production of anatomical parts used for didactic purposes [19]. The investigated structures can be measured and interpreted [27], and in the phalangeal horse joints the synovial structures can be observed [4]. At the same time, the horse head parts can be used to interpret the clinically relevant structures around the guttural pouch [15, 16]. Some cranial nerves such as N. hypoglossus, N. glossopharyngeus, N. vagus and N. accessorius may be affected in case of inflammation of the guttural pouchmucous membrane[15, 16].

Arterio-venous conjunction within the horse hoof region has been demonstrated for the first time using the S10 and E12 plastination method [12, 13]. These findings were confirmed by the method of corrosion. The blood flow-promoting structures were highlighted both in the terminal arch and in the blood vessels that penetrate through the bone channels to vascularize the keratogenic membrane of the dorsal part of the hoof [24]. Not only the intrabony blood vessels, but also the other arteries and veins hidden in the callous structure of the hoof, show this arterio-venous conjunction. Each artery is accompanied by two veins. With this mechanism, the venous blood is pushed to the heart and by the arterial pulse. In the horse's hoof sections affected by laminitis, one can observe the fine collagen structures of the equine distal phalanx suspension [1, 2, 3, 14]. In the encephalic sections produced using the P40 plastination method, we can notice the internal structures of the brain as well as the cranial nerves [31, 32, 33, 39]. (Fig. 5)

Another great advantage is the use of transparent plastinated sections, produced by the E12 method, for histological investigations and for electronic microscopy. For this purpose, fragments from the plastinated section can be collected and can be cut with a microtome.

In the last 40 years, there have been published scientific papers about the history of plastination[20, 21], but these publications have not discussed the possibility of scientifically using the plastination method as a research method.

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