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SmartPen®-Plastinate Integrated Tutorial System (S-PITS): A self-directed learning tool. *Baptista, Carlos A. C.. Department of Neurosciences, University of Toledo, College of Medicine, Toledo, OH, 43614, USA*

Self-directed learning has been identified as a promising methodology for life-long learning in health education. The LCME (Liaison Committee on Medical Education) is recommending flexible and innovated approaches that foster self-directed learning. The use of plastinated anatomical/pathological specimens provides a unique opportunity for self-directed learning. Plastinates are dry, odorless and free of formaldehyde. Therefore, they can be removed from the dissection/autopsy laboratories and brought to the classrooms/libraries. In addition, the integration of digital technology to plastinates promotes meaningful learning by providing guidance and more robust knowledge.

Methods: Design a software application to integrate the LiveScribe® Smart Pen® to plastinates.

Results: The S-PITS prototype consisted of a series of educational objects on anatomy created by a capture/play device using a dot-positioning system (DPS) in standard paper with printed microdots on its surface. The paper was attached to a silicon plastinate through a thumbtack using a permanent bonding agent. A series of narrative anatomy modules were recorded in wave format and encoded to LiveScribe® proprietary format. Two S-PITS modules were designed to teach the anatomy of the brain and the hand.

Conclusion: S-PITS is a platform for self-directed learning that integrates plastinates with digital technology providing flexibility for the study of anatomy and pathology outside the usual academic settings. In addition, they provide an interactive environment, structure and guidance to the student and a powerful educational tool to promote meaningful learning through the integration of words, sounds and visuals.

A comparison of dissection versus plastinated prosections to teach the anatomy of the hand. *Bennett-Clarke, Carol A. Carlos A. Baptista, and Richard D. Lane. Department of Neurosciences, University of Toledo College of Medicine, Toledo, OH 43614, USA*

Cadaver dissection of certain body regions such as the hands and feet can be very challenging, time consuming, and frequently unrewarding for medical students. The present study was designed to examine the impact of plastinated prosections on the efficiency of student learning in the gross anatomy laboratory.

Methods: Fifty-two first year medical students participated in a study conducted during a single lab session covering the dissection of the hand. All students were given a pretest, them randomly placed in 3 groups that either completed the standard dissection of the hand (group 1), completed the dissection as group 1 but with access to plastinated prosections (group 2), or used the laboratory session to study plastinated prosections of hands without performing a dissection (group 3). All groups used the same dissection guide during the session. At the end of this laboratory, all students completed a posttest followed by a brief survey. A faculty member evaluated final dissections completed by groups 1 and 2.

Results: No significant differences were noted in either the pre- or post-test results between the three groups. However, the mean time needed to complete the lab using plastinated specimens only (group 3) was half of that required by the two groups. There was no significant difference in time spent or quality of the dissection noted between the two dissection groups (1 and 2). The students in the “prosection only” (group 3) were significantly more satisfied with the laboratory experience based on ease of learning and time productivity measures.

Conclusion: These results suggest that plastinated prosections provide an effective alternative to student dissection of technically difficult regions.

Staining of sections planned for sheet plastination. *Dall, Annette M. and John Chemnitz. Neurobiological Science, University of Southern Denmark, 5230 Odense M, Denmark.*

Sheet plastinated sections provide an exceptionally good intermediate between macroscopic and microscopic anatomy. They are normally unstained but will get an even wider field of application if stained. The conventional protocols for histological staining are developed for thin tissue sections applicable for light microscopy, which are only a few µm thick. Sections made for sheet plastination are usually 2-5 mm thick, and hence the staining protocols have to be changed to secure solid colouring of the tissue.
Methods: We focused on the van Gieson protocol labelling collagen fibers in the connective tissue and the Klüver & Barrera method for myelinated nerve fibers. The relation between incubation time and colour penetrance of the tissue was studied for the solutions required according to the staining protocols.
Results: Staining protocols for conventional thin tissue sections were modified to be suitable for thick tissue slices planned for sheet plastination.
Conclusion: Staining of connective tissue and myelinated nerve fibers in thick sections may contribute to the understanding of the myofascial system.

Use of heart plastinated heart slices to assist echocardiography interpretation in the dog. *Latorre, Rafael, Alejandro Gomez, María J. Fernandes Del Palacio, Ricardo Sarria, and Octavio Lopez Albors. Dept. of Anatomy and Comparative Pathology, and Dept. of Medicine and Surgery, Veterinary Faculty, University of Murcia, Spain.*

The present work is aimed at obtaining a collection of plastinated slices of dog hearts corresponding to the standard protocol for the bidimensional (2D) echocardiography. This study is justified by the lack of abundant material in this subject and by both its educational and clinical applications.
Methods: Thirteen fresh normal dog hearts were fixed by dilation and processed by S10 silicon plastination (Biodur®). Also, two dogs without cardiopathies were explored by 2D echocardiography so as to obtain standard right parasternal (short and long axis), subcostal and left parasternal, caudal and cranial images. The plastinated hearts were knife sectioned according to the corresponding echo-images.
Results: The collection of plastinated slices displayed the heart anatomy of standard 2D echocardiographic planes with great detail and accuracy. Nevertheless, due to the process of fixation (by dilation) no comparison could be done with echocardiographs in ventricular systole.
Conclusion: The plastinated slices were anatomically accurate, durable and easy to manage, and considered appropriate for 2D echocardiographic training and clinical assessment.

Tridimensional anatomical model of the elbow joint of the dog. *Latorre, Rafael [1], Jorge Arredondo[2], Sarria, Ricardo [1], Sora, Mircea-Constantine [3], Lozanoff, Scott [4], Ayala, María D. [1], and López-Albors,[1] Octavio. [1]Department of Anatomy and Compared Pathologic Anatomy University of Murcia, 30100, Spain. [2]Department of Anatomy, Faculty of Veterinary Medicine and Zootechny, Autonomous University of the State of Mexico, 50000, México. [3]The Medical University of Vienna, A-1090, Austria. [4]Department of Anatomy, Biochemistry and Physiology, John A. Burns School of Medicine, Hawai, 96813 U.S.A.*

Developmental pathologies and traumatic lesions of the elbow joint are very common in dogs and most of them have a surgical solution; however, surgical planning is difficult due to the high complexity of this joint. 3D computed tomography models have proven useful when planning surgical approaches but do not always offer good definition of soft tissue structures such as blood vessels and nerves. The use of epoxy ultrathin plastinated slices (aprox. 400 µm) allows accurate description of complex anatomical regions with great definition and can be used for three-dimentional reconstructions. The aim of this work is to construct a 3D computer model of the anatomical structure of the elbow joint of the dog from plastinated ultrathin sections.
Methods: One elbow joint of a dog was used in this study. The whole fore limb was removed from the cadaver and the axillary artery injected with epoxy resin. It was frozen at -30ºC for 48 hours and a block containing the elbow joint removed. The block was plastinated by epoxy impregnation E12-E1-E600 (Biodur®) and cut into 0.4-0.6 mm thick slices with a contact point diamond band saw (Exakt®). The

plastinated slices were scanned and the images uploaded into the Windsurf® 3D reconstruction software.
Results: The thin plastinated slices provided good anatomical detail of the elbow joint, allowing the bony structures to be reproduced in 3D. Subtraction of specific structures was possible, permitting the elements in the model to be displayed in groups or as a whole, as well as rotated in the simulated 3D space. This procedure permitted a better understanding of the anatomy of the elbow joint of the dog and may be useful in assessing surgical or clinical problems in this complex joint.
Conclusion: The 3D model of the elbow joint of the dog obtained from ultrathin plastinated sections is a reliable tool for the study of this joint and could become useful for planning standard and alternative surgical approaches in this or other species.

Clinical anatomy of the relation between the temporomandibular joint and the middle ear in horses. *Latorre, Rafael [1], María J Rodríguez[1], Octavio López-Albors[1], Jorge Arredondo[2], Francisco Gil[1] and Amalia Agut[1]. [1]Dept. of Anatomy and Comparative Pathology, and Dept. of Medicine and Surgery, Veterinary Faculty, University of Murcia, Spain. [2]Dept Anatomy, Faculty of Veterinary Medicine and Zootecny, Autonomous University of the State of México, México.*

In horses, some of the clinical signs shown in the temporomandibular joint (TMJ) disorders, such as headshaking or head leaning are similar to those described for certain neurological and middle ear pathologies. The aim of this study is to demonstrate the relationship between the TMJ, the middle ear and surrounding structures in horses.
Methods: Heads from 6 Purebred Spanish horses were frozen at -30ºC for 48 hours. Blocks containing the TMJ and its surroundings were then plastinated by epoxy impregnation E12-E1-E600 (Biodur®). The epoxy blocks were cut in oblique sagittal 0.4-0.6 mm ultrathin slices with a contact point diamond blade saw (Exakt ®).
Results: Fibers of the articular disc and the articular capsule of the TMJ, especially from the caudal ligament, were observed running through the petrotympanic fissure and attaching onto the middle ear. The mandibular nerve was observed in close proximity to the medial aspect of the dorsal synovial pouch and fibrous caudal expansion of the articular disc.
Conclusion: There is a direct relationship between the TMJ and the middle ear in horses which may explain the aforementioned clinical signs. The close proximity of the mandibular nerve to the medial aspect of the TMJ components may also explain some of the malocclusion problems affecting horses with TMJ disorders.

The Brain Book: Plastination and lamination of brain cross sections. *Mitra, Aditi, Linda Saab, Lauren Marchese, Adriane Marchese, Ameed Raoof. Division of Anatomical Sciences/Plastination, University of Michigan.*

Plastination has proven to be an invaluable asset to the education of anatomy. With its use, specimens have been preserved in a way that is both durable and conducive to learning anatomy much more effectively than two-dimensional pictures and plastic models alone. In particular, brain slicing has been an effective method of visualizing the numerous tracts and deep internal structures held within the cortex. However, organization and fragility of such fine slices, as well as the vast amount of anatomy found within the brain, has hindered students' ability to sufficiently navigate these resources. As a result, it is important to develop a system which not only processes thinly sliced brain sections, but also organizes them in a way that both safeguards them for long term use and presents anatomical structures in a more interactive way.
Methods: Our objective is to enhance anatomy education by developing a hands-on, interactive, teaching tool for the University of Michigan's anatomy education needs. Through the collaboration of students well versed in anatomical research and medicine, we created a series of slides in which human brains have been thinly sliced transversely, sagittaly, and coronally. Next, each slice was plastinated and laminated using plastic lamination sheets. This ensures the slices are protected while also maintaining the ability to see the brain clearly. In addition to the brain slices, transparencies labeled with specific areas of the brain were placed over the plastinated brain slices thereby highlighting various anatomical structures. These areas were labeled using colored markers, where each color represented a different landmark. A color legend was

laminated along with the brain slices, correlating the color and anatomical structures.
Results: We created a tangible brain atlas allowing students to better visualize and understand the complexity of the human brain, providing a useful resource to facilitate anatomy comprehension with specimens that can be used independently or in conjunction with transparencies.
Conclusion: The brain atlas will improve the ability of students to learn brain anatomy and comprehend the dynamics of its intricacy. It will not only serve as a useful tool for visualizing the anatomical structures of the brain, but also provide a tangible and durable piece of anatomy that students can hold.

The posteromedial neurovascular bundle of the ankle: an anatomic study using plastinated slices.
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The aim of this study was to evaluate the topography of the posteromedial neurovascular bundle of the ankle. The anatomic relationship of the posteriormedial neurovascular bundle at different levels of the ankle was studied as an aid in planning minimally invasive surgery. A thorough knowledge of the local anatomy is a prerequisite prior to attempting release of the tibial nerve, or when using the posteromedial portal for ankle arthroscopy.
Methods: A sectional anatomy study was performed on twelve intact right male cadaver lower limbs. The distal third of each limb was cut and the foot positioned in the neutral position. The measurements were performed at the level of the tibiotalar joint, tip of the medial malleolus and at the sustentaculum tali.
Results: The tibial nerve is predicted to be 11.8 Â± 2.4 mm and the posterior tibial artery 16.7 Â± 3.8 mm anterior to the calcaneal tendon at the level of the tibiotalar joint. At the tip of the malleolus medialis, the tibial nerve is 14.3 Â± 2.5 mm and the posterior tibilal artery 22.1 Â± 4.1 mm anterior to the Achilles tendon. The medial plantar nerve is situated at the sustentaculum tali level 8.4 Â± 3.4 mm and the lateral plantar nerve 16.1 Â± 3.1 mm posterior to the sustentaculum tali.
Conclusion: A posteromedial portal made at the level of the tip of the medial malleolous is safe, effective, reproducible and advantageous for an endoscopic tarsal tunnel release or ankle arthroscopy.

Use of plastinated specimens to convey learning concepts in Sports Medicine and Kinesiology.
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Reduction in anatomy contact hours, budget reductions, and changes in student learning approaches have prompted novel instructional approaches to maximize efficiency. While computer-assisted instruction provides an important supplemental approach, “hands-on” opportunities remain critical for fully appreciating anatomical concepts. The purpose of this study is to develop a series of plastinated specimens to demonstrate common sport injuries and assess their usability for learning musculoskeletal injury evaluation.
Methods: Dissected specimens were dehydrated, degreased, impregnated, and cured following standard room temperature plastination methods. An assessment tool using a Likert scale was designed to evaluate the usefulness of the plastinates for conveying associated learning issues. Students from various programs and backgrounds were presented with the models following didactic presentation of injury mechanism, symptom, and clinical testing.
Results: Plastinates provided realistic representations of injuries. Preliminary data suggested that the plastinates were helpful in understanding the injured structure and its surrounding relationships. Most health-profession students believed the injury models would enhance their skills in palpation and special testing.
Conclusion: Plastination may be a cost effective method for exposing students to unique human anatomical materials. The plastinated injury models are useful learning tools that enhance the students’ understanding of sports injuries from the anatomical perspective.

Plastination of fresh and old embalmed human lungs using modified S-10 technique *Dhingra, Renu [1], Sankat Mochan[1], Sanjeev Lalwani[2] and Rani Kumar[1] [1]Department of Anatomy, [2]Department of Forensic medicine, All India Institute of Medical Sciences, New Delhi, INDIA.*

Well preserved gross specimens become an integral part for understanding their three dimensional anatomy, thereby giving clarity to spatial co-relations to an aspiring surgeon. Many fixatives are used for preservation of biological tissues, formalin being the most popular globally. Formalin-fixed specimens have certain limitations like formalin fumes, use of gloves, masks, deterioration with handling etc. To overcome these disadvantages, plastination is being used as these specimens are dry, odorless and require minimal aftercare. We have successfully plastinated specimens such as liver, kidney, heart and knee joints using the S10 technique with certain improvisations.

Methods: In the present study, we planned to standardize the plastination of human lungs using the S 10 technique as they contain air spaces which can cause considerable shrinkage. Twenty-one fresh lungs (group I) and 15 old embalmed lungs (group II) were divided into subgroups based on variation in forced impregnation mixture. All the lungs were then subjected to dehydration, forced impregnation (with or without solvent) and curing.

Results: The morphological features of the lungs were evaluated using qualitative (color, flexibility) and quantitative criteria (shrinkage % in surface area and volume). The difference in mean % shrinkage of surface area and volume was found to be statistically significant ($P<0.05$) among with and without solvent groups in both fresh and old embalmed lungs. **Conclusions:** The fresh lungs impregnated with solvent in the impregnation mixture showed superior color preservation, were more flexible and had less shrinkage when compared to fresh lungs impregnated without solvent in impregnation mixture and old embalmed lungs.

Plastinated knee: A model for arthroscopic and diagnostic purposes. *Kumar, Rani[1], Neha JAIN[1] , Sanjeev Lalwani[2] and Renu Dhingra[1], [1]Department of Anatomy, [2]Department of Forensic medicine.All India Institute of Medical Sciences, Ansari Nagar, New Delhi,INDIA.*

Plastinated specimens serve as excellent models not only for teaching purposes but also to provide hands-on experience for aspiring surgeons. Plastinated cross-sections of body and brain also serve as excellent comparable models for radiologists for analyzing MRI, CT and Sonography images. The present study was undertaken to plastinate the knee region for the arthroscopic study of the knee joint.

Methods: Freshly embalmed knee regions were plastinated, for the arthrosopic study. The sections of knee region were then cut to compare the anatomy of knee joint with MRI images. Fifteen knees were collected from the Department of Forensic Medicine at AIIMS. The knees were washed, cleaned and fixed in 5-8% formalin. Each joint was filled with 120-250 ml of fixative and plastinated using the standard S-10 silicone technique.

Results: The interior of the knee joint was viewed through an arthroscope by making a port on the anterolateral side of the joint. The structures seen were the ligamentum mucosum menisci, intercondylar notch, infrapatellar fat pad, and the anterior and posterior cruciate ligaments. By making more ports and changing the position of the arthoscope and manipulating the freshly embalmed plastinated knee joint, the interior of the joint was viewed for clinical assessment without disturbing its anatomy. Coronal and sagittal sections of the plastinated knee were also made and compared with MRI images of the knee joint.

Conclusion: Plastinated specimens can serve as a very good model for surgical procedures and for comparisons with MRI images.

Room temperature plastination of stained brain slices. *Sagoo, Mandeep and Adds, Philip, St George's Hospital Medical School, London SW17 0RE, United Kingdom*

The standard method for plastination with Biodur® S10/S3 silicone involves low-temperature dehydration in a volatile intermediary solvent (acetone or methylene chloride) followed by forced impregnation under vacuum at -15°. However, some institutions have been reluctant to install low-temperature impregnation equipment because of health and safety concerns. Room-temperature plastination has the advantages of low cost and simplicity of set-up, and avoids the potential safety hazards associated with low-

temperature impregnation. Previous studies at St George's have shown that a low-temperature dehydration/ room temperature impregnation protocol for Biodur® S10/S3 can produce results comparable, if not equal, to the standard low-temperature method. Studies on brain tissue have shown that slices impregnated at room temperature retain excellent colour definition. Shrinkage was below 5%.

Methods:. In this study, formalin-fixed brain slices were first stained with Mulligan's stain for grey matter, before undergoing dehydration in acetone at -30° C and vacuum impregnation with S10/S3 at room temperature. Measurements of the slices were taken at each stage of the process to monitor shrinkage.

Results: Colour definition of the stained grey matter remained good after plastination. Shrinkage was acceptable, and did not detract from the value of the slices for neuroanatomy teaching. The stain has thus far not faded on exposure to light.

Conclusions: Cold-temperature dehydration and room-temperature impregnation can be used to plastinate brain slices stained with Mulligan's stain. This further extends the potential applications of room-temperature plastination

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Public Education with Plastinated Specimen *Sui, Hong-Jin , and Shengbo Yu. Department of Anatomy, Dalian Medical University, Dalian 116044, P.R. China*

Although the development of anatomy is more than five hundred years old, the structures of the human body remain unknown and mysterious to the general public. Public education of anatomical science is a strong desire for anatomists. Anatomy is a unique subject since its research findings are achieved mainly by dissecting real human bodies. The history of systematic dissection of human corpses began in ancient Alexandria. Many anatomical museums in the world (which are still open to the public) have a history of hundreds of years, containing specimens preserved in formalin. Public education of anatomical science reflects a considerable far-reaching significance. But it is not as easy as many people thought to conduct a public education of anatomical science. Even though a majority of people accept the public display of anatomical specimens, a few visitors might be critical and some even question the validity of those exhibits. In China, plastinated specimens are contributing to public education. The specimens are dry and have no odor compared with specimens preserved with formalin, allowing the public to observe and to learn about the human body more directly. Public education using plastinated specimens has also been effective in promoting body donation. The Chinese have a stronger traditional view of human bodies. The opinion of a large majority of Chinese visitors has been positively changed because of our public education with plastinated specimens. The plastination technique creates a new age for the public education of anatomical science.
