Review Article

ISSN (0): 2455-5274; ISSN (P): 2617-5207

Plastination Technique and Its Impact on Medical Education

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Abstract

Introduction: Plastination has been one of the most effective preservative methods for organic tissue during the last four decades. In this technique, water and lipid content present within biological tissue samples are substituted by polymers (silicone, epoxy, polyester), resulting in dry, durable, and odourless specimens. Plastinated specimens are now used as teaching tools and various medical disciplines, such as anatomy, pathology, radiology, surgery, and so on across the world. Since its development by Gunther von Hagens in 1977, plastination is getting increasing acceptance by the day and proving itself to be an excellent resource material for both teaching and learning. This review highlights the origin, procedure, types, significance, and drawbacks of plastination along with its ethical aspects.

Keywords: Plastination, Plastinated specimens, Plastinates, Anatomy Specimens.

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Received: 18 February 2022 **Revised: 18 April 2022** **Accepted: 29 April 2022** **Published: 30 June 2022**

Introduction

Well-preserved specimens are an essential requirement in the teaching and learning of Anatomy. There is a wide disparity between the curricular demand and actual availability of cadavers owing to a dearth of voluntary body donation. In such a circumstance, plastination provides the most promising and viable alternative to conventional formalin embalming. Plastination is a method of long-term preservation of perishable biological tissue in a life-like state. It helps in building up a collection of anatomical specimens which are easy to handle and long-lasting. The basic principle of plastination is replacing the fluid of embalmed tissue with curable polymers. The resulting product is termed plastinate. The optical and mechanical properties of plastinated specimens are defined by the choice of polymers. Plastination has gained acceptance throughout the world. The review aims to highlight different aspects of plastination and its significance.[1,2,3,4]

Omit the term Review

Origin of Plastination

The two finest anatomical artists of the Renaissance, Leonardo da Vinci and Andreas Vesalius, employed anatomical drawings to better comprehend the workings of the human body. Professor Gunther von Hagens, a German-born physician and anatomist was intrigued by their work and has pioneered the process of plastination. According to the German encyclopedia the word “plastination" is derived from Greek. (plassein = to shape, to form). He invented this process in 1977 in a laboratory at the German University of Heidelberg following several trials and errors. Later, he patented the process and registered his company Biodur for supplying materials required for plastination to medical institutions. To promote the work, the International Society of Plastination was established and its journal was published. He was the founder of the Institute of Plastination in Heidelberg and organized a number of workshops cum exhibitions of plastinated human bodies in Japan and Germany. A number of modifications and variations of the core process have been suggested over the years.[5,6,7,8]

The Standard Method of Plastination

The plastination procedure consists of replacing tissue fluids and tissue lipids with a polymer, under a vacuum. It consists of four steps: 1. Fixation, 2. Dehydration, 3. Impregnation, and 4. Curing.

Fixation

Fixation refers to the process of organs and tissues preservation by treatment with chemicals to resist autolysis and putrefaction. The selected bodies first go through formalin embalming. Then the embalmed cadaver is dissected carefully to procure the required specimen. The specimen for the sectional study is prepared by obtaining sections in suitable planes (transverse, coronal, or sagittal) depending on the region to be studied. The customized specimen is then immersed and a large volume of fixative (10 times the volume of the specimen). The special tissues are infused or infiltrated with fixative. Hollow organs (for example, the heart) are dilated during fixation. Another method called freeze fixation may be employed by treating the embalmed specimen with a mixture of acetone (95 parts) and formalin (5 parts) at minus

25 degrees celsius over two weeks. This method simultaneously serves the purpose of dehydration.

Dehydration

The specimens are kept immersed in an organic solvent like acetone (or ethanol) for at least a period of three weeks with a serial change in concentration on a weekly basis. Acetone acts as a dehydrating and defatting agent under freezing conditions and is miscible with the polymers employed for plastination. However, acetone is costly and is inflammable in nature. This limitation is to be considered. Acetone replaces tissue water over a period of 4–5 weeks. When no more water bubbles come out, dehydration is deemed to be complete. After three weeks, the specimens are left outside for 24 hours to allow the leftover acetone to evaporate.

Forced Impregnation

Forced impregnation is the most important step. It involves the replacement of dehydrating agent (acetone) by a curable polymer. The specimen which is by now fixed and dehydrated is placed in an airtight vacuum chamber containing a liquid polymer, which is fitted with a vacuum pump. The negative pressure created by the vacuum sucks the acetone out of the tissue in a vapor form. Low temperature is used during the procedure. The time required for successful completion of impregnation is dependent upon the specimen used along with the nature of the polymer. The most commonly used polymer is silicone rubber (S10) followed by PEM 27 and epoxy resin.

Curing

Curing is the final step where the polymer impregnated specimen is exposed to heat, ultraviolet light, or gas depending on the polymer used. As a result of this treatment, the polymer molecules polymerize and cross-link to yield a hardened specimen. Curing requires several months to get completed. A plastinated specimen ranges from a whole cadaver to a small viscera or a slice of tissue.[3,4,8,9,10,11,12] [Figure 1 and 2]

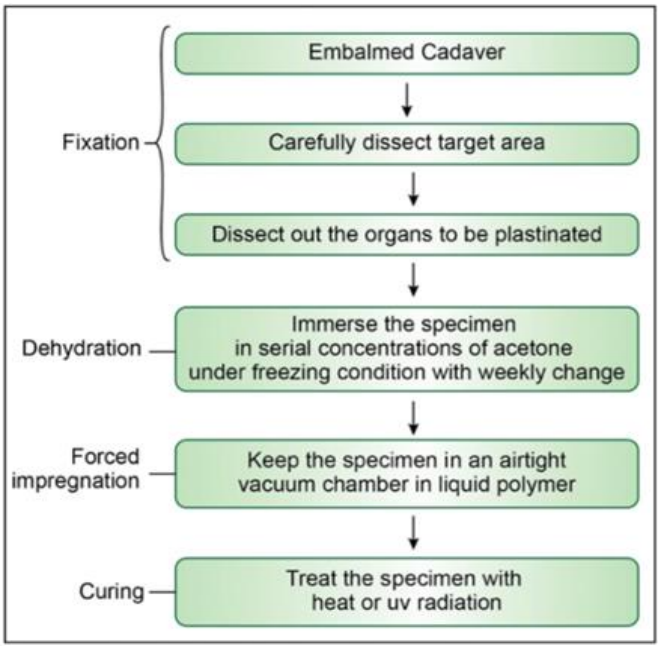

Figure 1: Flowchart showing steps of plastination

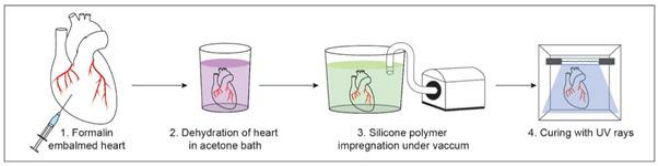

Figure 2: Schematic diagram showing steps of plastination

Equipments and Chemicals Required

Airtight containers, vacuum chamber fitted with suction pump, a gas chamber for gas curing, deep freezers and other pieces of equipment such as glass rods and sheets, pvc pipes, clamps, curable polymers (such as silicone, epoxy resin, polyester, and so on) dehydrating agents such as acetone or ethanol, hardeners such as S3, gas cure S6, and so on.[13]

Types of Plastination According to its Purpose.

Plastination is classified according to its purposes into didactic plastination for teaching and learning, scientific plastination for research and experiments, and commercial plastination for exhibition and sale.[14]

Types of Plastination According to the Polymer Material used

1. Silicone polymer (S10) is used for the preservation of the whole cadaver or only limb or viscera.[15,16,17]
2. Epoxy polymer technique (E12) to create transparent sections of the body at different levels or sections of tissue.[18,19]
3. Polyester polymer technique (P40) to create sections of the brain.[20,21]
4. Light-weight plastination employing xylene and silicone.[22]
5. The Quickfix® Procedure to produce plastinated cadaveric hearts by using Quickfix® and amyl acetate in equal proportion for impregnation.[23]
6. Melamyne procedure: Melamyne (polymer) and xylene (intermediary volatile solvent) for plastination.[24]

Types of Plastination Based on Nature and Dimension of Tissue

1. Plastination of whole organ or body.
2. Luminal cast plastination of hollow organs.
3. Sheet plastination for sectional plastinates.[2]

Handling and Storage of Plastinates

Plastination if done properly, yields everlasting specimens with appropriate care.

Significance of Plastination as a Teaching-Learning Tool.

1. Ideal teaching tool for gross anatomy for the excellent preservation of structures and their relations.
2. It simulates the real dissected cadaveric specimen and provides a sense of realism which translates into effective learning. They are considered high-quality resource materials for rapid learning.
3. It enables the students the visualization and understanding of three-dimensional topography from the different viewing angles.
4. Plastination helps generate anatomical databases. Plyastinated tissues help to reconstruct high-resolution 3D

and holographic models based on which interactive applications and websites are being designed to introduce students to the virtual laboratory for self-directed learning. Plastinated models can be used as source material for illustration in the anatomical atlas.
5. Specimens can be displayed in a variety of customized manners as required for study and research.
6. It can also provide supplementary add-on material for teaching embryology or histology. Plastinated specimens can be deplastinated with sodium methodise and used for histology. Plastinated embryonic or fetal tissue helps understand the human developmental process.
7. Sheet plastination (Using the E12 or P40 techniques), is best suited for the investigation of structures at the mesoscopic level which is an intermediate between the macroscopic and microscopic levels. Sheet plastination contributes the most in studying sectional anatomy, with three major regions of research application: A. Better understanding and interpretation of radiological anatomy by comparison with imaging modalities like computed tomography scan, magnetic resonance imaging scan, and 3D rendering. B. soft tissue patterning, C. Studying interfaces between hard and soft tissue.
8. Plastinated alimentary and respiratory passages are a great tool to teach and learn endoscopic procedures.
9. Specimens are durable, dry, odorless, non-toxic and noninfectious, easy to manoeuvre and store.
10. Forensic and pathological specimens can be put up for museum display.
11. It serves as a substitute for cadavers in countries where cadavers are scarce.[14,25,26,27,28,29,30,31,32,33,34,35,36]

Drawbacks of Plastination

1. Time-consuming and skill dependent.
2. Require expensive equipment and patented imported raw material.
3. Acetone used as a dehydrating agent is inflammable in nature.
4. Lacks the haptic feel of a wet specimen.[14]

Concerns Regarding Commercial Plastination.

Plastinated specimens have been showcased as a part of a public exhibition. Body Worlds Exhibition and Real Bodies Exhibition are the two most notable ones in this category. These events attract large footfalls, massive media coverage and invite discussion regarding their legal, ethical, and cultural standpoints. The business involving human corpses are vehemently opposed by legal bodies, churches, religious groups, and ethics committee. From a religious point of view displaying a dead body for a commercial purpose is a matter of disrespect to the deceased. Legally speaking the obtaining of consent for plastinated bodies to be used for this purpose is a serious issue. It's a matter of legislative debate whether the consent for whole body plastination will be valid for conducting plastination on individual body parts and organs. Moreover, most of the volunteers who sign up for body donation, prefer to be plastinated as a whole. They are not comfortable with the idea of being sliced or skinned as a part of plastination. To look at it ethically, only didactic and scientific plastination should be permissible for teaching and research. Any form of entertainment or financial benefit is unethical. The International Federation of Associations of Anatomists (IFAA) expressed serious disapproval regarding the display of plastinated human specimens in commercial events (IFAA, 2018). All the commercial plastinated exhibits during import should be classified under customs as items belonging to the anatomical collection, rather than putting them under the art collection category. Permission from competent authorities should be mandatory for hosting any plastination exhibition within India. The selling of plastinates in any form or by anyone should be strictly monitored and reported.[39]

Standard Practice of Body Donation Programme for Plastination

1. The donor who intends to pledge their body for plastination will give a declaration to this effect during their lifetime.
2. The donor should be explicitly informed regarding all the possible ways their body may be utilized to produce specimens. Detailed documentation of informed consent should be mandatory.
3. There should be no provision of financial compensation to the willing persons.
4. Sales of plastinated products will be restricted only to qualified users. Qualified users refer to accredited individuals or institutions who will make use of the specimens exclusively for educational and research purposes.[40]

Storage and Handling of Plastinated Specimens

Plastination if done properly, will yield, in principle, everlasting specimens —provided they are handled with due care and caution. It is advisable to wear gloves while holding the specimens and to use laser pointers or soft rubber pointers during teaching and demonstration. Any sort of potentially damaging manipulation namely pulling, poking, pinching, prodding, and dividing should be strictly prohibited. Plastinates can be stored in the open air for an indefinite period as long as the ambient temperature keeps between the range of 50 C to 350 C and the relative humidity is below 50%. Cleaning modalities of plastinated specimens include careful dusting with a hand duster or using pressurized air, gentle wiping down with a microfibre cloth soaked in soap water, delicate brushing with a soft wet toothbrush, and slow rinsing with water. Finally, the specimen should be made dry by using a paper towel. The damaged specimens can be repaired by applying super glue or silicone glue to the concerned structures and securing them for an optimum time for letting them set properly.[41]

Conclusion

The importance of plastination as a teaching-learning tool is ever increasing in the field of medicine. This is evidenced by the publication of thousands of articles in high-impact journals in the field of surgery, orthopedics, neurology, anatomy, radiology, and so on. Plastination has great potential in the academic field and it should be explored further for teaching, training, and research purpose in the days to come. What is required is a standard operating protocol and legislative guideline regarding the implementation and utilization of the process.

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How to cite this article: Pal AK, Bhanarkar U, Ray B. Plastination Technique and Its Impact on Medical Education. Acad. Anat. Int. 2022;8(1):1-5.

DOI: dx.doi.org/10.21276/aanat.2022.8.1.1

Source of Support: Nil, **Conflict of Interest:** None declared.