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PLASTINATION AN INCIPIENT WAY OF LEARNING ANATOMY-A REVIEW

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ABSTRACT

Background: Anatomy is the backbone of medical field and it has utmost importance in clinical aspects. As emerging world and inquisitiveness for knowledge the population heading towards this field has increased with the increase in demand for cadavers. Embalming is an age old technique which has upgraded with time and reached this journey till plastination (with its self-upgradation techniques). Plastination is an art of anatomical embalming. Plastination, developed by Gunther Von Hagen in 1977 is the technique of tissue preservation in its life-like state for long-term. **Objective**: To describe plastination techniques and various application in medical education. **Design:** Articles were searched from internet using various search terms such as embalming techniques, plastination, teaching aids in anatomy, etc. Selection of the articles where made from review article point of view. **Result:** Plastination is a process of anatomical specimen preservation by forced impregnation method with curable polymers like silicon, epoxy or polyester resins. In this process, water and lipids in biological tissues are replaced by curable polymers which are hardened, thereby resulting in dry, odorless and durable specimens. The plastination techniques based on the type of the polymer used for impregnation. The technique consists of four steps: fixation, dehydration or defatting, forced impregnation and curing or hardening. **Conclusion:** Plastination is a boon in preservation technique and great aid in teaching anatomy with its various applications in medical field. The important thing about this technique is that each and every part of the body and tissue can be preserved and used for educational purposes. With evolution of the technique some lacunae are always there, here ethical issue, religious dilemma and even sex plastinates are matter of immense concern and it shouldn't be ignored. Besides this the invention is an artistic phenomenon accepted and utilized by various anatomists worldwide.

KEYWORDS: Preservation, Plastination, Teaching aid.

INTRODUCTION

Anatomy, the spine of medical science and the ladder towards the medical practice was recognized as a discipline hand of science. The history of preservation and preparation of anatomical specimens is inevitably linked to the history of the study of anatomy itself and the history of development of anatomy is the history of attitude of people towards dissection.[2] Dissection is a royal road, which follows a pass through difficult mountains to pleasure and peace of mind. Learning anatomy through practical dissection amalgamates the clinical knowledge relevantly.[2] So in that case in order to learn anatomy the study of gross specimens are needed and to fulfil this demand for the upcoming generations there is an utmost need of preserving the cadavers from ongoing natural processes of decomposition and putrefaction. To fulfil this demand, the preserving techniques from mummification to cryopreservation have been in long process since decades. Upgrading the knowledge from previous drawbacks led to the exploration of plastination technique. With plastination several earlier approaches have merged. The pre-decessors of plastination can be summed up as: [22]

- Exsiccation and dehydration techniques
- Polymer embeddings and
- Impregnation with hardening substances.

Professor Gunther Von Hagen, a German physicist and anatomists, created, named and developed the process of plastination technique in 1977. The term plastination itself has its origin from a Greek word "plassein" meaning" to shape or to form." In these processes, water and lipids in biological tissues are replaced by curable polymers mostly silicone, epoxy, and polyester which then will harden and finally result in natural looking, dry, odorless and durable specimens. Many applications of plastinated specimens have been prepared by the standard techniques of plastination. These specimens have be considered as an important tool for teaching and exposition purpose. The technique and substances used for plastination is upgradation within the technique itself. This review is intended to give a survey of the

applications of the plastination technique and to serve as an introduction to technique itself.

Purpose-Plastination was invented and developed as a technique for preserving biological tissue, and producing anatomical specimens for studying human and animal anatomy. The added potential of plastination for clinical research was discovered later. Clinical plastination is a special area of scientific exploration and clinical education with particular interest in the field of applied medicine. Clinical plastination brings new facts in clinical research and provides new opportunities for using plastinated specimens to expand clinical manner of thinking. It could be made available in clinical centers to allow improved effectiveness of teaching of ultrasound, and radiographic and surgical anatomy and techniques. It is advantageous to combine routinely used diagnostic and surgical procedures with plastinated specimens, as it gives a better understanding even to the specialist in terms of clinical necessities. Sectioning hard anatomical blocks plastinated with the epoxy technique offers great new opportunities for anatomical and clinical research. Improving research projects and quality of education in anatomy.

Principles of Plastination[10]

The underlying principle of plastination is that water and lipids are removed from the tissues and they are replaced by a plastic (curable polymer). In plastination different types of polymers are used. The most commonly are epoxy, silicone rubber, and polyester. For obtaining the best plastinated specimens, the polymer used, must have the following desirable properties:

1. It must have lowest possible viscosity in uncured state.
2. Its refractive index of the polymer should be different from that of tissue (otherwise a transparent specimen would be obtained).
3. Resin activator mixture (base and catalyst) should have a long action time or a relatively long liquid phase life so that, it allow time for impregnation of the tissues.
4. Curing should not be inhibited by the tissue.
5. Mechanical properties of the polymer should be appropriate when cured that is, it should be rubber like to stimulate a nature state, or firm to permit its surface to be ground.
6. It should be affordable.

Procedure

The process of plastination is successfully done by halting the decomposition.[10] Plastination consists of processes whereby tissue fluids and fat are slowly replaced by a curable polymer under vacuum conditions. This technique allows us to obtain clean, dry, resistant preparations of unlimited duration, which can be examined without gloves or any other type of protective equipment and do not require any special treatment or storage conditions. It also avoids daily exposure of students and teachers to harmful products because they are free of toxic substances, such as formaldehyde, phenol, alcohols etc.

Types of Plastination[1]

Although all plastination techniques have a similar basic protocol, depending on the type of polymer used and the type of anatomical preparation, the general classification is:

Silicon impregnated specimens are resilient and flexible and are mainly used for teaching purposes (S10).

Specimen produced with polymerizing emulsions are as opaque as the silicone specimens but are rigid and to some extent breakable. The use of this technique is in thick body slices exhibiting a superb contrast between fat tissue, which show up white, and all other more intensively stained parenchymas.

Transparent body or organ slices are produced with epoxy resins (E12).For research purposes these slices allow study of the topography of all body structures in an uncollapsed and non-dislocated state. In addition the specimens are useful in advanced training programs in sectional topography.

Opaque brain slices are impregnated with polyester resin; they allow a unique discrimination between fiber and nuclear areas (P35).

Techniques[2]

There are four basic steps in the standard process of plastination

Fixation (embalming)

Dehydration (fluid removal)/defatting

Forced impregnation

Curing or hardening followed by

Finishing and storage

1. Fixation: Specimens are fixed in 10% neutral buffered formalin (NBF) for 24-48 hours; a longer fixation time results in loss of color. Therefore, large specimens are injected with fixatives to hasten fixation.

2. Dehydration/defatting: This step is compulsory because polymers cannot directly replace lipids and water. Dehydration is done by placing specimens in graded series of alcohol 70%, 80%, 90%, and three changes of absolute alcohol for 48 hours each. The final exposure to absolute is monitored with a hydrometer to assure the water concentration is less than 1%.Defatting or degreasing is the removal of excess fat by defatting agents such as acetone and dichloromethane /methylene chloride. Cold acetone defats slowly but acetone at room temperature defats much more quickly.

3. Forced Impregnation: This is the most important step in plastination, It is the replacement of the intermediary solvents (acetone 56°C, methylene chloride 40°C) while the polymers have low vapor pressures and high boiling points. The intermediary solvent is continuously extracted from the specimen as gaseous bubbles and is replaced by the polymer solution. Impregnation is completed bubbles cease.

4. Curing or Hardening: This is done using gaseous hardeners (e.g. silicone), ultraviolet light and heat. Gas curing is specially developed for plastination using silicone resin. In this technique, the curing agent is applied in a gaseous form to the specimen. The impregnated specimens are kept in a closed chamber and are exposed to a gaseous hardener (curing agent) which is continuously circulated in the atmosphere of the chamber until curing is completed.

5. **Finishing and storage**: Plastinated specimens can be made more appealing by trimming the unwanted areas or flash polymer with a scalpel, a dilute detergent or a lubricant can be applied to clean, and the surface can be made smooth by buffing to get a display specimen. As far as storage is considered required specimens can be mounted on Perspex stands purposes and others can be easily stored in plastic bags at room temperature.

Benefits over other preservation methods[4]

Mummification, an ancient method developed in Egypt to preserve the remains of royalty over ages, is a technique that dehydrates the body and wraps it in linens. The body was dehydrated in sun and then mummified. The major disadvantage with this technique was that the integrity of the tissue is lost and the tissues undergo shrinkage and loss of details.

Formalin use, introduced in 1896, can be considered the most traditional method of preserving specimens. In this process, the specimens are usually saturated with formalin and kept in open or closed glass bottles. These specimens are very difficult to work with due to strong unpleasant odor and need for a lot of maintenance as the specimens can rapidly deteriorate or dry out. Formalin also poses health hazards like irritation to nose and eyes. Further, most of the time, formalin bleaches the tissues.

This was followed by embalming techniques with colored solutions where the body fluids are replaced by colored solutions and further advanced to use paraffin impregnation introduced in 1925.

In the 21st century, the preservation techniques are so advanced to the level of cryopreservation; here, the body fluids are replaced by cryoprotectants which protect the cells of the body from cryo-injury during the storage process. This technique aims at preserving a dead body or tissue as long as the technology can that caused the death catch up and aid in reviving the dead and correcting the ailment that caused the death in the first place. The disadvantage with this technique is that the body so preserved is not intended for academic anatomy studies and taking samples out of cryocan for studies can be detrimental to the specimen.

Advantages[1]

1. Unlike formalin preserved specimens that release formaldehyde gas which has irritating smell, plastinates are odorless.
2. Plastinated specimens can be used for a long period of time without decay, deterioration and discoloration. Therefore, plastination techniques can be used to preserve museum specimens.
3. Plastinates required little or no maintenance, and can easily be carried to lecture halls for demonstrations.
4. Bone fragments can be preserved in their normal position using plastination techniques, while fractured specimens can be protected by plastination.
5. Wet brain fractures can be permanently preserved using plastination techniques.
6. Plastination can be studied in the classroom or library, while formalin preserved specimens can only be studied in the laboratory.

Disadvantages[12]

1. Process is technique sensitive, time consuming, and hence needs a dedicated pathologist.
2. Beginner has to do a lot of trial and error during the process to achieve the desired outcome which might lead to consumption /wastage of rare and unusual specimens.
3. Slightly more expensive and needs more equipment than the conventional laboratory methods.
4. Process needs lot of post curing works such as trimming, polishing, coloring, and mounting to obtain a good display specimen.
5. Learning anatomy on only plastinated specimens is a compromise because of its limitations in terms of tactile and emotional experience that is provided by wet cadavers.
6. Deplastination is not possible with all types of resins.
7. Has a limited application in oral pathology, as the technique is more suitable for large specimens.
8. Includes shrinkage and inability to manipulate superficial structures to study deep structures.
9. The process is technique sensitive, time consuming, expensive and deplastination is not possible with all types of resins.

DISCUSSION

Ethical considerations and when to use plastination[7]

Plastination allows a long term preservation of tissue sometimes for a very long period of time. Ethical and legal guidelines dictate how bodies are allowed to be used in medical teaching and research, and also prevent misconduct or abuse, such as commercialization of body parts or neglecting ethical aspects or disrespect of human remains. However, the legal conditions are far from satisfactory and do not prevent the export or import of body parts across countries, or ethically unacceptable exhibitions of plastinated cadavers. It is therefore even more important that the written consent form includes how a human body shall or shall not be used. One needs to realize that once tissue is plastinated, it is no longer offensive and can be handled with gloves. Thus, plastinates can be placed in any context, not necessarily related to anatomical teaching. It is therefore essential to

have specific ethical and legal guidelines to define what is acceptable or prohibited.

Consent for displaying body as plastinate is a major issue. Religious objections considering plastination against reverence towards human body should also be considered. Also donations of bodies for plastination would deprive the health service of organs for transplant. Promotion and creation of sex plastinates is another matter of immense concern.

Plastinated specimens as a teaching aid in anatomy[3]

Plastinated specimens are dry, durable, and odorless which give a true life-like appearance. Plastinated specimens have become important milestone in medical education. They have become an ideal teaching tool not only in anatomy but also in pathology, obstretics, radiology and surgery. Teaching of topographic anatomy along with its clinical application in clinical years is now considered essential. It's very difficult to display formalin fixed prosected parts in the hospital wards. In these circumstances the plastinated specimens would be an ideal teaching tools in medical teaching. Human cadavers remain the best way to provide 3-dimensional pictures of anatomy to medical students. The human gross anatomy laboratory experience continues to play a major role in the objective of learning anatomical concepts and the relationships that are later applied to understanding of clinical situations. The time spent on repeated reading of a textbook is less effective than the time spent thinking about the subject and visualizing a structure and its relation to the surrounding structures. At present, plastination has established itself as an indispensable contributor to the teaching armamentarium of clinical anatomists.

Teachers have accepted plastinated human specimens as superior specimens in relation to synthetic models, on account of their ability to reflect anatomical variations. Even ultrathin plastinated slices can be obtained and have been used to construct precise three-dimensional computer models of anatomical structures teaching greatly benefits from all kinds of plastinated specimens. Replacing specimens stored in formalin or alcohol, the dissected material can be literally grasped without wetting the students infers or their textbooks. Their great advantage over traditional histology techniques lies in the ease with which it is possible to move between the macroscopic and the microscopic. The decay of this material is an impediment to all morphological studies, teaching and research. Thus, the preservation of biological materials becomes essential for them to be used as an educational tool.

Applications[1]

1. Because of the resilience and flexible nature of silicon impregnated specimens, they can be carried to the classrooms for teaching purposes where students can study and understand the relationship between muscles, bones, nerves and vessels without dissection. Note: dissection can only be carried out in the laboratories.
2. Specimens produced with polymerizing emulsions can be used to study parts of the body where there are fat deposits, such as mammary glands (breast), subcutaneous layers of the skin and transverse sections of the abdominal cavity.
3. Transverse, longitudinal and oblique sections of the body, organs and body parts can be studied in three dimension using transparent nature of the slices, all structures are visible and can be differentiated using contrast medium.
4. Because brain tissues are soft, pliable and some parts can easily break off when preserved in formalin, opaque brain slices produced by plastination without breaking. Plastination also has the ability to differentiate between fiber and nuclear areas of the brain, giving the students better understanding of the brain.
5. In parts of the world where there is difficulty in obtaining cadavers for dissection due to cultural and religious reasons, plastinates can be used to study all body parts, even in three dimensions.

CONCLUSION

Plastination has been so far considered as an ideal technique for long term preservation of well dissected specimens and body slices. It is not only best for preservation but also an excellent adjunct in teaching anatomy. Plastinated specimens are easy to handle without chaos and are much more accepted by the students to learn anatomy in more better way, as we all know that traditional guided dissection can't be replaced by plastination but this technique does provide additional learning tool to understand complex human anatomy tridimensionally. Anatomy is even perceived and projected to researches worldwide through this modernized technique. The potential of plastination lies in its ability to preserve delicate structures and their interconnections, enabling them to be traced microscopically Plastination is a shrine in which even untrained people can look at the body in a new way. However, it appears that many anatomists have not yet realized the revolutionary significance of plastination for anatomical research the phenomenon of plastination has provided another option for anatomists by increasing the range of specimens for teaching and research.

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