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Plastinates: Possible tool for medical education in the near future: mini review

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Abstract

Background: The objective of this paper is to describe the various types of plastination techniques and their application in medical education.

Methods: Articles were searched from internet databases using search terms such as medical education, plastination, plastination techniques, embalming, cryopreservation, etc. Articles that met the selection criteria were selected for the review.

Results: The search result showed that Plastination is a technique that uses curable polymers to replace body fluids in order to prevent decay and deterioration. The plastination technique was invented by Gunther von Hagens in 1977. The plastination technique is divided into four types based on the type of polymer used for impregnation: silicon impregnated specimens, specimens produced with polymerizing emulsions, transparent body or organ slices, and opaque brain slices. The technique consists of four steps: fixation, dehydration or defatting, forced impregnation in a vacuum, and curing or hardening.

Conclusion: Plastinates, products of plastination, are used for teaching and research purposes. Because of their flexibility, resilience and transparent nature as well as the ability to carry them to class rooms, they can be used to replace formalin-preserved specimens in medical education.

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Introduction

Medical education is the bedrock of every medical career, with its ultimate aim to train highly skilled and knowledgeable professionals/health care workers who put patient care above self-interest.[1] Training in the basic medical sciences (preclinical) section is the most important part of medical education as it gives students a basic, foundational knowledge before going to the clinical section where all knowledge received during the preclinical section will be applied. Training at the preclinical section cannot be achieved without the use of certain tools, equipment and specimens like microscopes, cryostat and cadavers. Tissues, organs and body parts are preserved for various reasons, including teaching, research, record-keeping (museum specimen) and for forensics. Specimens are preserved in various concentrations of formalin, alcohol or bouins fluid.[2] Preserved tissues, organs, body parts and the entire body are the most important educational tools in anatomy education as they have unique properties that gives them superiority over plastic models.[3] Despite the advantages of formalin preserved specimens over plastic models, there are several disadvantages with the use and handling of formalin preserved specimens, including repulsive and irritating smells, loss of color associated with long term use, and difficulty in retaining the three dimensional orientation of hollow and branching specimens.[4] In order to tackle the problem of the odor of formalin preserved specimens and to minimize contact with potentially carcinogenic formaldehyde vapor, other techniques of preserving body parts for teaching purposes have been explored.[5] Cryopreserved specimens are alternatives to formalin preserved specimens but are less practical due to scarcity of a constant power supply in most underdeveloped and developing countries. Additionally, hardening of specimens coupled with the time taken to thaw the specimens before use and the formation of ice crystals have rendered cryopreserved specimens no

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better than formalin preserved specimens.[6,7] The aim of this paper is to describe various types of plastination, its techniques and application in medical education.

Materials and Methods

Databases searched were Science Direct, Google Scholar, PubMed, Journal Citation Reports, Science Citation Index Expanded, Directory of Open Access Journals, Scopus and Science Direct. The criteria used to select articles were as follows:

- Articles that highlighted advances in medical education.
- Articles that described the various methods of preserving cadavers for medical education. e.g., embalming (formalin preserved specimen), cryopreservation and plastination.
- Articles that described plastination techniques and the history of plastination.
- Articles that described the advantages and disadvantages of plastinates over formalin preserved specimens

The key words used for the search were as follows: medical education, advances in medical education, role of formalin preserved specimen in medical education, role of plastinates in medical education, role of cryopreserved specimen in medical education, plastination, plastinates, plastination technique, history of plastination, cryopreservation, embalming, and advantages of plastination. The curator of the museum at the National Postgraduate Medical College of Nigeria (NPMCN) was also interviewed. Articles that met the selection criteria were selected for the review.

Results

Nineteen articles related to the research that met the selection criteria were selected for the study. The articles were used to describe plastination, plastination techniques, history of plastination, types of plastination and the advantages and disadvantages of plastination as follows.

Plastination

Plastination is a technique that employs the use of curable polymers to replace the fats, water and body fluids so as to preserve biological specimens for long period of time preventing decay and deterioration.[8,9] The term plastination was derived from the Greek word "plassein," which means to form or to shape.[10] The plastination technique was invented by Dr. Gunther von Hagens in Heidelberg, Germany in 1977. Since then it has been applied in anatomy, pathology, biology and forensic sciences in the preservation of specimens that are dry, odorless, non-toxic, and non-infectious and yet retain their natural color and structural components even at histological levels.[11,12] There is a difficulty in getting enough cadavers for anatomical education in Africa because of lack of body donation programs and religious reasons in addition to increasing numbers of medical students. Hence, Dawson et al[13] reported that plastination is the most promising method for preserving specimens for medical education. This is because a single body can be preserved by plastination techniques and be used for a very long period of time compared to formalin preserved bodies that can be dissected once. Therefore, plastinates are cost effective when compared to formalin preserved bodies which have to be acquired and preserved with every need. This can delay teaching and research in areas of limited resources or difficulty in acquiring bodies.

History of plastination

Dr. Gunther von Hagens discovered plastination techniques while he was experimenting with various plastics on kidney slices at the University of Heidelberg in Germany. Von Hagens patented the plastination technique and established a company called BIODUR to further promote his invention and to provide the chemicals used for plastination through one supplier.[14] The Anatomical Department in Vienna was the first to use plastinated specimens in their laboratory outside Heidelberg.[12] Similarly, the Health Science Center of Texas also equipped their pathology laboratory with plastinated specimens.[15] By 1982, the first international conference on plastination was held in San Antonio, Texas, USA; however, an international society for plastination was not established until the third conference in 1986. Subsequently, the first journal of the society was published in 1987. Von Hagens established the Institute for Plastination at Heidelberg in 1993.[16] Von Hagens participated in the exhibition of plastinated bodies in Japan in 1995. He also championed the first German "BODY WORLDS" (Körperwelten) exhibition in Mannhein in 1997 before moving to Dalian Medical University in China as a guest professor.[13] This was because the German government refuse to recognize the Institute for Plastination as a research institute in Germany.[16] In Nigeria, the first plastination workshop was organized by the National Postgraduate Medical College of Nigeria at Lagos in August, 2014. The workshop gave rise to the first plastination laboratory in 2015 which subsequently organized museum techniques and plastination workshops in September 2016 and August, 2017 respectively. The laboratory was able to plastinate different specimens of human body parts and animals using silicon impregnation (S10).

Types of plastination

Based on the type of polymer used in impregnation, plastination techniques are divided into four types that produce different specimens.

1. Silicon impregnated specimens (Figure 1): opaque, resilient and flexible, used for teaching purposes (S10).
2. Specimens produced with polymerizing emulsions

(Figure 2): opaque, rigid and breakable, these allow discrimination between fatty and other tissues.
3. Transparent body or organ slices (Figure 3): impregnated with epoxy resins (E12) and used for research purposes to study the structure of all body parts in three dimension (3 D).
4. Opaque brain slices: produced with polyester resins and used to differentiate fibers and nuclear areas (P35).

Plastination techniques

Plastination techniques consist of four basic steps; fixation, dehydration/defatting, forced impregnation and curing or hardening.

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 alcohol 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 temp defats much more quickly.[17]
3. Forced Impregnation: This is the most important step in plastination; it is the replacement of the intermediary solvents (acetone or methylene chloride) with curable polymers (silicon, epoxy resin, polyester) in a vacuum. The specimen is placed in a polymer solution in a vacuum and because the intermediary solvents has high vapor pressure and low boiling point (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 when bubbles cease.[12]
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.[8]

Advantages of plastination

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 (e.g., plants and animals that are on the verge of extinction).
3. Plastinates required little or no maintenance, and can easily be carried to lecture halls for demonstrations.[18]
4. Bone fragments can be preserved in their normal position using plastination techniques, while fractured specimens can be protected by plastination.
5. Wet brain tissues can be permanently preserved using plastination techniques.
6. Plastinates can be studied in the class room or library, while formalin preserved specimens can only be studied in the laboratory.

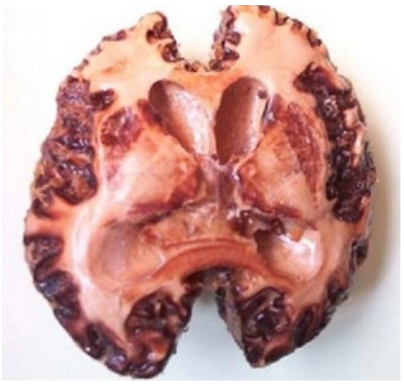

Figure 1. Brain slice produce by silicon impregnation.[19]

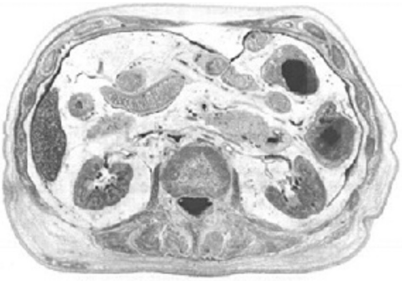

Figure 2. Body slice (transverse section) produced with polymerizing emulsions.[12]

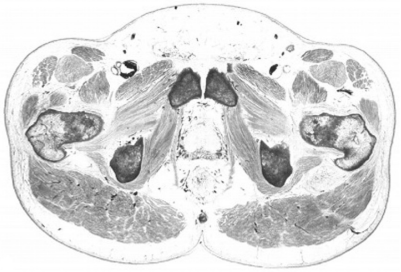

Figure 3. Transparent body slice (transverse section) produced with epoxy resins.[12]

Disadvantages of plastination

1. Plastination techniques are sensitive, time consuming and require qualified and dedicated personnel.
2. The ability to dissect and locate structures will give students technical surgical skills; this is not possible when using plastinated specimens.
3. Plastinates lack the wet texture of a formalin preserved specimen, which is nearly natural.

Discussion

From the result, it is evident that plastination is an advanced method of preserving human and animal specimens for medical education and because of its advantages over both formalin preserved and cryopreserved specimens, it can be an alternative method for preserving tissues, organs and whole bodies for medical education.

Application of plastination in medical education

1. Because of the resilience and flexible nature of silicon impregnated specimens, they can be carried to the class rooms 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 body or organ slices; because of the 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 techniques can be used for long periods of time 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 for medical education because they can be used to study all body parts, even in three dimensions.

Conclusion

Plastination techniques can be used to preserve tissues, organs, plants, human, and animal parts, for teaching, research and preservation of museum specimens. Unlike formalin preserved specimens that produce toxic and irritating fumes and can only be handled with gloves, plastinates are odorless, non-toxic, can be handled without gloves, can be used for a very long period of time, and requires little maintenance/storage. Therefore, they can replace formalin preserve and cryopreserved specimens as a tool for medical education in the near future.

Ethical approval

The review was approved by the Postgraduate Board, Department of Human Anatomy, University of Maiduguri.

Competing interests

The authors declare that there is no conflict of interest.

Authors' contributions

NID conceive the idea, SHG and TWJ provide editing and technical support, the manuscript was written and approved by all authors.

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