PLASTINATION TECHNIQUES.

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Abstract:

Plastination: *A preservation technique where a dead specimen can be processed and preserved almost in their natural state. Done in 3 types; Whole body plastination: whole organism preserved, sheet plastination; body sliced into sheets/slices which are preserved and Lamina plastination where a cavity is preserved and surrounding tissue dissolved. In both types biological tissue soluble fats and water are replaced with polymer & then hardened to attain nearly natural looking and durable anatomical specimen. Products of this process; Plastinates are clean, dry, smell less, harmless, need little care, perfect for museum display and medical education. We discuss its historical background, types, principle, procedure and ethical considerations.*

Keywords: *Plastination, silicon.*

BACKGROUND.

Definition: Plastination is Preservation technique where a dead specimen can be processed and preserved nearly in their natural state (1–3) .

Principle: Lipids/soluble fats and water in the biological tissues are replaced with synthetic component/curable polymer for example, polyester resin, epoxy or silicone and then after specimen is hardened to obtain a natural looking and durable anatomical specimen. The polymer maintains the specimen smell less, clean, dry and need little care after. Products of this process: Plastinates are harmless compared to formalin preservation. More so, they are perfect museum specimens and medical education tools. Specimen to be/preserved can be; Entire organism. The entire organism preserved for study, public view or Specific organs like kidney, heart, liver. A specific organ or body cut into slices of interest preserved (1).

In ancient times, Organisms, living tissues after death underwent putrefaction and decomposition caused by microbial organisms such bacteria, fungi or protozoa and also due to continued biochemical reactions in the body yet bodies needed to be preserved for some time for different purposes such as public display, historical/cultural monuments and to delay burials . As a result, scientists of that era invented conventional body preservation methods such as mummification, smoking, salting and freezing (4).

Mummification is an Egyptian preservation technique invented around 2150±500 BC. This became highly marketed/demanded technique and was highly demanded. Many scientists studied and contributed to evolution of body preservation. For-example, Sir. Robert Boyle attempted to change the trend by studying if the wine spirit can preserve a snake (5) . A first scientific attempt to preserve tissues for anatomical study.

Embalming was first attempted by Jan Swammerdam who injected wax and turpentine in a dead body in order to solidify it internally and prevent the decomposition (4–6).

In 1863, Wilhelm von Hoffman invented the gas “Formic Aldehyde” (Formaldehyde). In 1893, Ferdinand Julius Cohn used formalin (40% aqueous solution of formaldehyde gas) to preserve a cadaver. Since then, formalin, phenol and glycerin are being used to embalm the cadavers globally (5,7)

In 1975, a German scientist named Dr.Gunther Von Hagen, while he was scientific anatomical assistant at the Anatomical institute of Heidelberg University, observed for the first time when specimens were embedded in plastic blocks. He wondered why plastic was powered around the specimen instead of inside the specimen to stabilize it from within. After a series of research experiments, He made his first plastinated presentation in January 1977 and in March 1977 he submitted his process to the German patent office. In 1979, Von Hagen’s plastination process presented was recognized after series of ethical considerations. After public awareness of the process, donation and plastination process started getting body donors that raised about 20,000 donors for plastination annually (1).

Types

Classified according to the end product type or the type of resin that has used in the plastination process. More than past 30 years, many resins have been tested for their potential use in the plastination procedure leading to production and discovery of many plastination techniques with each with its advantages and limitations. However, most commonly used plastination resins include Polyester, Epoxy resin and Silicone (2).

Entire organism, organ /Silicone (S10): Specimens are processed and preserved as a whole in 3-Dimension matter (8,9).

Sheet plastination (P40): Specimen cut into slices, processed and preserved for illustration and teaching. This facilitates production and preservation of thin, transparent body slices of unparalleled transparency, vibrant colors and size. It involves two types Sheet plastination with epoxy method and Sheet plastination with polyester method depending on the resign type used (8,10).

Process/Procedure: There 2 procedure types depending on the type of specimen and type of resign used.

A. SILCONE PLASTINATION: (2,9):

The whole or organ of the body is preserved in 3D matter using silicon as a plastic polymer resign in the following 5 steps.

Body Reception and Fixation (Embalming): The first step of this type of plastination. Formaldehyde or other fixative solutions are coursed via the arteries to destroy all bacteria and prevent tissue decomposition. Lasts for about 3 to 4 hours.

Anatomical Dissection: Skin, fatty and connective tissues are removed so that individual anatomical structures and elements are strategically prepared. Takes the duration of 500-1000 hours of labor.

Dehydration & defatting (Removal and fat Removal): Actual 1st phase of plastination. Plastination parts away with conventional preservation techniques. Water and soluble fats are dissolved from the body in a bath of acetone. In freezing conditions (-25° C), acetone draws out all the water & is replaces it inside the cells. Last for about 4 months.

Forced impregnation: This is the most Central phase of the process. The Specimen is placed in bath of liquid polymer such as rubber, silicone, polyester/Epoxy resin. Vacuum is created which causes acetone to vaporize at low temperature leaving the cells and cells draw inside the liquid polymer to penetrate every cell. Also the body will not be shrunk by vacuum use. This lasts 2-5 weeks up to 2 months.

Positioning: The body is still flexible and can be strategically aligned as desired. This is done with wires, needle clumps and foam blocks. This requires skilled anatomical knowledge, strong aesthetics and lasts for weeks to 2.5 months depending on skill of anatomists.

Curing/Hardening: The Last stage where Gas, light or heat is introduced depending on polymer used to protect against decomposition in enclosed chamber (Air tight bag). This forms chain extensions and cross linkages of the polymer. The result is a durable Plastinates that retain most of their original properties and precise weight. The whole stage lasts for 1.5 to 2 months.

B. SHEET PLASTINATION (3,8,11):
1–3-millimeter semi-transparent tissue slices are obtained after removal of tissue fluid and partial substitution of tissue fat with curable epoxy resign. The specimen preserved can be macro or microscopically examined although the technique requires more preciseness. Takes place in the following steps.

Body Reception and Fixation (Embalming). This starts with the will of the living person who signs a body donation card that when he/she dies, the body can be donated for plastination and museum display. After the death of potential donor, the body is picked up to the plastination center. The body is then fixed using fixative agents such as formalin or kerling solution is coursed via the arteries to destroy all bacteria and prevent tissue decomposition.

Cold dehydration. This is the most significant step where a specimen is frozen at 70^{o} C-75^{O} C for 7-10 days for complete freezing. It's then removed and sliced using butcher saw band to produce sheet slices. However clean the dust from the saw to prevent formation of artefacts on sheet samples.

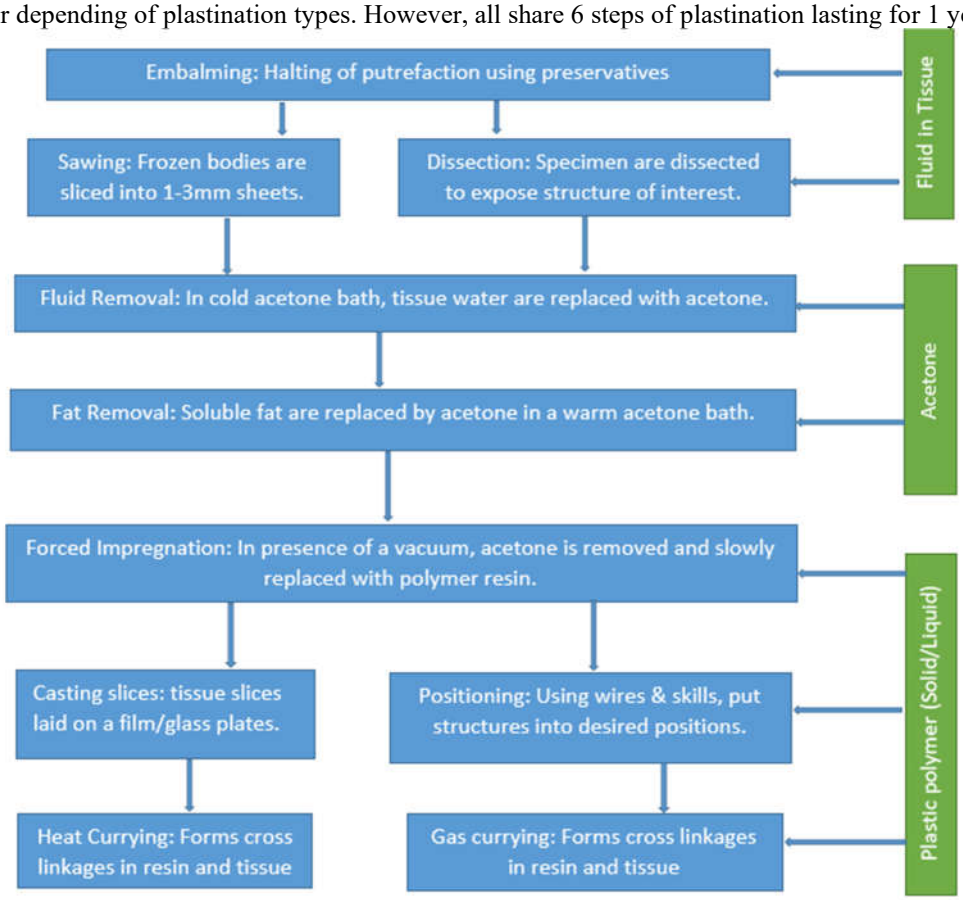
Dehydration & defatting (Removal and fat Removal). The Slices are submerged in acetone bath at -25^{o} C for dehydration. Acetone draws out all the water and soluble fats while replacing it inside the cells. This dehydration bath can be changed for almost 3 times to ensure complete removal of water. The bath with a final/third acetone concentration of 98.5% acetone produces a high transparent slices. It's worth noting that high lipid content specimen may be dehydrated with stronger dehydration agents like methyl chloride.

Forced impregnation. In this stage, the polymer is forced into the tissue with the use of a vacuum. Specimen is placed in bath of liquid polymer like rubber, silicone, polyester/Epoxy resin. In vacuum presence, acetone solvent from cellular and interstitial places is substituted with epoxy impregnation mixture. The role of the vacuum vaporizes acetone at low temperature leaving the cells and liquid polymer drawn inside to penetrate every cell. This procedure last for about 36-48 hours at 5^{o} C while 32 hours at room temperature.

Curing/Hardening. This is forming the cross linkages between the plastic polymers infiltrated in the tissue. Can be achieved in any of the 2 ways. Flat chamber method: slices are properly placed in flat glass container and treated with Epoxy resin again for transparent result in a chamber and air removed prior chamber closure. Specimen is placed at 15^{o} C for 24-48 hours and then placed in an oven at 45^{o} C for 4 days then removed and cools down and sheets can be recut to desired size. Sandwich method: Impregnated slices are floated over a pool of decerated casting mixture kept on the foiled sheet. This is faster than flat chamber.

General Steps for the 2 types of plastination (5,8,11,12).
Chemicals required
- Acetone
- Methylene chloride
- Silicone polymer
- Catalyst to prepare silicon molecules
- Chain extenders cross linkers for silicone molecules
- Apparatus for fixation.

Figure 1: Schematic diagram showing 2 types of plastination processes.
Processes differ depending of plastination types. However, all share 6 steps of plastination lasting for 1 year.



Plastination Uniqueness over other preservation methods: (2,10,12,13) .

- Easy storage of preserved specimens even in a shopping bag with appropriate labeling.
- Preserves perfectly soft/fragile tissue sample such as intra-cerebral hematoma can be preserved perfectly and made durable for future use.
- No toxic fumes or foul smell. Usually, it's hard for students to study due to the smell of formalin leading to impairment student interest. However this is not present in plastination.
- In a long run, it's cheaper than conventional formalin based method.
- Specimen lasts longer: Up-to 40 years, 10 times more than that of conventional method.
- Preserves all structures in their almost natural state thus able to give a more detailed features.
- Sheet plastination, easens the study of topographical anatomy in detail.
- Can also preserve parasites present in flesh like larvae in the putrid flesh, for demonstration.

Limitations/disadvantages:

Despite its effectives in specimen preservation, it still encounters limitations (3,6,13,14).

- Plastinated specimen are relatively inflexible (attributed to silicone presence in tissues) thus hard to reflect the specimen and demonstrate deeper anatomical features. Plastinated specimen are not ideal for use in clinical practices like ultrasonography & endoscopy.
- Moreover after plastination completion, tissue hardens that further dissection is difficult. Therefore, the final dissection has to be done before the procedure.
- The procedure is sensitive technique requiring skilled manpower and time consuming.
- Plastination laboratory development requires a lot amount of investment (human resource, equipment and accreditation).
- Risk of health occupational hazard on poor chemical handling where exposure to the chemicals used causes health disorders. Acetone may cause respiratory and dermal irritation in short term exposure in low concentration (250ppm-1000ppm). High concentration (>12000ppm) can cause more severe symptoms like vomiting and unconsciousness. In mice prolonged exposure to acetone with concentration >19000ppm has shown to produce reversible decrease in the absolute brain weight of cadaver. Additionally, acetone causes visual impairment and sensitivity loss on long time exposure. In silicone impregnation, Ethyl silicate, Hydroxyl-terminated polydimethy isiloxane are reported to cause dermatitis and allergic reactions respectively on long term exposure whereas exposure to Dibutyltin dilaurate used in sheet plastination causes allergic reaction and asthma on vapors inhalation by the operator (10).
- Exposure to pathogens especially during the early processing of samples. Nevertheless use of Personal protective equipment and formalin specimen fixation before processing destroys pathogenic organisms, can reduce the pathogen exposure risk.

Ethical considerations

After successfully inventing the process, Dr. Gunther was faced with Ethical issues on acquisition of the bodies while observing ethical principles of conduct, protection of human and animal rights. In most countries, there are formulated laws in regards to donation of human bodies after death (2,13). However, individuals who agree for their bodies to be plastinated, used for illustration and medical education, are required to give, (1,5,10) .

- An informed consent for both plastination and for display of their plastinated parts in museums.
- Consenting donors are assured anonymity of their identity and their cause of death.
- Also the plastinated specimens' are sorely entrusted to recognized and accredited educational institutions, museums, research organization and never to private individuals or dealers.

Uganda has recently passed the organ donation and transplant bill waiting for the assent by the president. With this law, more preservation techniques like plastination will take effect (Parliament Of Uganda, 2021).

Conclusion

Despite some limitations faced, plastination remains a much better preservation technique than the traditional methods. Even though some ethical questions have been recorded, many donors willing to undergo the process gives a good image of how plastination to the public and how it has improved health care education.

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