JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

PLASTINATION: A MODERN TECHNIQUE FOR LONG-TERM PRESERVATION OF ANATOMICAL SPECIMENS

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Abstract: plastination is an effective alternative to formaldehyde-based methods for the preservation of biological materials. It is a modern technique that enables long-term preservation while maintaining the structural integrity of the specimens. The plastination process involves four main stages: fixation, dehydration, impregnation, and curing. Based on the type of polymer used, plastination techniques are classified into silicon, epoxy, and polyester methods, each with specific applications in anatomical studies. The procedure requires specialized equipment, including a vacuum chamber, vacuum pump, and deep freezer, to ensure proper processing and optimal results. Overall, plastination offers a safer and more durable approach to specimen preservation compared to conventional formaldehyde-based techniques.

Keywords: **plastination, anatomical preservation, silicone, epoxy, polyester, vacuum impregnation**

INTRODUCTION

Plastination is an advanced technique used to preserve biological specimens. The word Plastination is derived from the Greek word "Plassein" meaning 'to shape' or 'to form. Plastination is a technique that uses polymers to preserve bodies, body parts, anatomical specimens and surgical specimens in a state closely resembling the living condition, maintaining them lifelike, durable and indefinitely preserved without significant surface morphological modification.[1] Dr Gunther Von Hagens a German anatomist in 1977 developed this technique. In this method the tissue fluid is replaced with a curable polymer. The main features and advantages of plastinated specimens over formalin preserved specimens are, that they are dry, odourless, and non- toxic. It is easy to handle and can use for educational and exhibition purposes. Apart from anatomy, plastination is applied in many other departments like pathology, forensic, zoology, botany, pharmacology and many more.

Spatial orientation of organs and other body parts are essential for learning anatomy. Models and formaldehyde preserved specimens are traditionally used for this purpose. However, models have limitations because they do not accurately represent the exact structure and relationships. Discovered in 1867 by German chemist August Wilhelm von Hofmann, formaldehyde (methanal) became the fixation and preservation icon for biological tissues and anatomical specimens and is commonly used in morphology laboratories due to its low cost, rapid tissue penetration, and long preservation capacity.

Formaldehyde is a known human carcinogen identified by the international agency for research on cancer. Anatomy students and faculties are frequently exposed to formalin which causes respiratory distress, skin irritation, headaches, nausea, dizziness, burning sensation of eyes, nose and throat, lacrimation, mood changes, insomnia etc. Faculties of the anatomy department are in continuous exposure to formaldehyde. The respiratory symptoms such as productive cough, breathlessness and tightness of chest were significantly more frequent among formaldehyde exposed persons.[2]

Although dissection of the human body is an essential component of teaching and learning anatomy, exposure to formaldehyde can be minimized by using plastinated organs instead of formaldehyde preserved specimens for demonstrating dissected organs. In the search for an alternative to formaldehyde preservation, a new technique called plastination emerged in the late 1970s. Plastinated specimens are odourless, moisture-free, durable, non-toxic, maintenance-free, and prevent students, technicians, and faculty from coming into contact with formaldehyde[3].

OBJECTIVES:

1. To identify the different methods of plastination used for anatomical specimen preservation
2. To compare plastination with conventional formalin- based specimen preparation
3. To evaluate the advantage of plastinated specimen over formalin- preserved specimens in teaching anatomy

Equipment needed for plastination

1. Vacuum chamber
2. Vacuum pump with a regulator
3. A freezer set to -25^0 C
4. Vacuum tubing
5. Glass jars

Chemicals

1. Acetone
2. Formalin
3. Polymers

Stages of plastination

Plastination process mainly comprises four stages – fixation, dehydration, impregnation and curing. Among these, fixation and dehydration are preparatory process for plastination. Fixation is usually carried out using formaldehyde to preserve the structural integrity of the specimen and to prevent decomposition. The specimens that have already been preserved in formaldehyde are generally preferred for plastination, as fresh specimens may undergo putrefaction and produce an unpleasant odour. Any fixation method using 5-20% formalin can be used for fixation.

Following fixation, dehydration is performed to remove water and soluble lipids from the tissues. This step is essential because the water molecules present within the specimen must be completely removed before impregnation with polymers. Dehydration is commonly achieved using organic solvents such as acetone, which replaces the water content within the tissues. The cooled fixed specimen is immersed in acetone at -25^{0}C. During the dehydration stage of plastination, specimens are placed in acetone at approximately -25 ^{0} to prevent tissue decomposition and minimize distortion. At this low temperature, enzymatic activity and microbial growth are greatly reduced, thereby preserving the structural integrity of the specimen. Additionally, cold acetone facilitates a gradual replacement of water within the tissues without causing excessive shrinkage or damage. The low temperature also helps maintain the natural morphology, colour, and consistency of the specimen. Thus, dehydration at -25 ^{0}ensures effective water removal while preserving the fine anatomical details essential for high-quality plastinated specimens. The volume and duration of acetone needed depends on the size of the specimen. Acetone should be changed thrice. If the specimen is fatty, keep the specimen in the acetone in room temperature for some more time to dissolve the lipids. Specimens prepared in epoxy plastination need an extra defatting bath in methylene chloride to improve their transparency. Once dehydration is complete, the specimen becomes ready for the subsequent stage of polymer impregnation. When dehydration is performed at room temperature, the rapid action of acetone leads to excessive extraction of water and lipids, resulting in increased tissue shrinkage and distortion. Higher temperatures also permit residual enzymatic activity and microbial growth, which may cause tissue degradation and unpleasant odor. In addition, rapid dehydration can damage delicate structures and compromise the natural morphology of the specimen. Consequently, improper dehydration at room temperature may lead to poor polymer impregnation, reduced durability, and inferior-quality plastinated specimens."

If non-dehydrated specimens are used, the residual water interferes with the replacement of tissue fluids by polymers. As a result, proper impregnation does not occur, leading to incomplete preservation. The specimen may remain soft, discoloured, or may even undergo decomposition over time. Additionally, the presence of water can cause artifacts such as tissue shrinkage, distortion, or microbial growth, ultimately compromising the durability and quality of the plastinated specimen. Therefore, thorough dehydration is essential to ensure effective polymer infiltration and long-term preservation.

Forced impregnation: This step is performed in a vacuum chamber. Here the acetone saturated specimens are immersed in liquid polymer. It involves replacement of acetone by a polymer. Once the specimen is placed in the vacuum chamber, with a vacuum pump the pressure is slowly lowered. The liquid vaporizes. This vapour is aspirated by the vacuum pump. The extraction of the acetone creates a vacuum inside the specimen which is penetrated by the polymer. After some time, pressure should be gradually reduced. When the bubbling ceases remove the specimen and allowed to drain. The impregnation process in plastination is performed under vacuum to facilitate the removal of the dehydrating agent (commonly acetone) from the specimen and its replacement with a polymer such as silicone, epoxy or polyester. When vacuum is applied, the boiling point of acetone is significantly lowered, causing it to vaporize at low temperatures. As the acetone evaporates from the tissues, it creates a negative pressure within the specimen, which allows the liquid polymer to be drawn deeply and uniformly into the cellular and intercellular spaces. This process, known as forced impregnation, ensures thorough penetration of the polymer, prevents tissue shrinkage, and preserves the structural integrity of the specimen. Without the use of a vacuum, complete impregnation would not occur, resulting in poor preservation and inferior quality plastinated specimens.

Curing: The curing process differs depending upon the polymer used for impregnation. The polymer hardener used for silicon specimen hardens over a period of time. The specimens are placed on a platform above the volatile accelerator in an airtight container. Initially polymer expands and oozes out from surface which must be wiped off until surface gets hardened. Epoxy resin impregnated specimen should undergo heat treatment at 45^0. Specimen impregnated with polyester is cured by a 45 minutes UV light exposure.

Finishing and storage: The unwanted areas can be trimmed using a scalpel. The plastinated specimen can be stored in plastic bags in room temperature.

Types of plastination:

Plastination techniques are broadly classified based on the type of polymer used and the characteristics of the final product. The major types include silicon, epoxy, and polyester plastination, along with sheet plastination. Silicon plastination (S10 technique) is the most widely used method. Silicon polymer S10 is suitable for putrefiable macroscopic specimens. The impregnation or processing mixture consists of a silicon polymer and the added hardener. Hardener causes gradual thickening of silicon. Silicone plastination is the most versatile technique which can be used for the cadavers, organs, portions and slices. Fresh or formalin-fixed (embalmed) specimens can be plastinated with this technique. It produces dry, odourless and flexible specimens that closely resemble natural anatomical structures. These specimens are durable and suitable for routine teaching and demonstration of gross anatomy.[4]

Epoxy plastination (E12 technique) is primarily used for the preparation of thin, transparent sections of anatomical specimens. This technique provides excellent clarity and allows detailed visualization of internal structures, making it particularly useful for studying cross sectional anatomy and correlating with radiological imaging.

Polyester plastination (P35 and P40 techniques) is mainly employed for brain specimens. It produces semi-transparent sections with enhanced contrast between grey and white matter, thereby facilitating the study of neuroanatomy.

Sheet plastination involves the preparation of thin slices of organs or whole-body sections, typically ranging from 2-5mm thickness. Depending on the polymer used (epoxy or polyester), these sections may be transparent or semi-transparent and are highly useful for sectional anatomy and imaging correlation.

Epoxy sheet plastination techniques were developed to obtain thin transparent body slices with high anatomical detail. The thickness for epoxy sheet plastination should be between 1.5 to 3mm. The impregnation material is prepared using Epoxy E12 resin with E1 hardener. This mixture is reactive and temperature sensitive, and for this reason, total impregnation time under vacuum at room laboratory temperature should not last for more than 20-24 hr. Casting of impregnated slices is done in either flat chambers or by the so-called sandwich method in either fresh mixture or the one used for impregnation. Curing is completed at 40°C to allow a complete polymerization of the epoxy-mixture.[5]

Potential health risks and limitations linked to Plastination Practices:

Compared to formaldehyde-based preservation, plastination is considered a safer method for the preservation of anatomical specimens. But the process involves exposure to various chemicals and physical conditions that may pose occupational hazards if proper safety measures are not used. The incidence of life-threatening medical problems from acetone exposure is very rare. Acetone toxicity affects almost all body systems, including the nervous, respiratory, cardiovascular, and endocrine systems.[6]

The plastination process is technique sensitive and time consuming and also require trained manpower. It is expensive and many of the polymers need to be imported. The emotional and tactile experience provided by a wet cadaver is not provided by the plastinated specimen.

Advantages of plastination

The life of biological specimen is limited. Frequent use of specimen for teaching disrupts its structure and appearance. Plastinated slices of brain are excellent for teaching cross sectional anatomy. Thin brain slices preserved in formalin are easily damaged, whereas plastinated brain sections can be used for a long time.

CONCLUSION:

Plastination has emerged as an effective and advanced technique for the long-term preservation of anatomical specimens, offering significant advantages over conventional preservation methods. The present review highlights the various methods of plastination employed for the preservation of anatomical specimens, including silicon, epoxy and polymer techniques. The various stages of plastination techniques were explained with their mode of action. A comparison between plastination and conventional formalin-based preservation demonstrates that plastination provides superior durability, better preservation of structural details and eliminates the hazards associated with formaldehyde exposure. Once prepared, plastinated specimens can be used repeatedly for teaching and demonstration without deterioration, thereby reducing the need for frequent specimen preparation. This not only saves time and labor but also ensures consistent availability of high-quality anatomical materials. In this context, plastination not only improves the quality and lifespan of anatomical specimens but also promotes respectful and sustainable use of human tissues. Thus, it represents a valuable advancement in anatomical science balancing educational needs with ethical responsibility and safety considerations.

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