

Plastination: An Innovative Modern Approach to Cadaveric Preservation for Medical Education

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ABSTRACT

In today's Hi-tech era plastination technique has achieved tremendous importance. Although plastination is increasingly recognized worldwide as an innovative tool approach to medical education. The scarcity of cadavers with the rapid increasing number of medical colleges, particularly in remote areas, alarms the need for an alternative and sustainable approach to medical education. Therefore, plastinated specimens is a durable, non-toxic and water resistant. An innovative educational tool that can complement to conventional cadaver-based teaching. As anatomy forms the foundation of medical education, there is an ever-increasing need for effective teaching & learning resources that can address the easy orientation & quick understanding into deeper relationships. In contrast to formalin-fixed specimens, which may have limitations related to odour, handling, preservation and long-term usability. Plastinated specimens provide high-quality lifelike anatomical models that can be repeatedly handled and studied. Participants can clearly visualize the appearance, appreciate the texture, friability, and toughness of the tissues. The lack of human cadavers further exacerbates the difficulties in medical education, limiting hands-on experience and understanding of complex spatial relationships.

Keywords: Plastination, Cadaveric preservation, Polymers & Advances in Medical Education.

Methods: For gross plastination polymer were used Plastodur silicone S- 18 & for sheet plastination Plastodur Epoxy E-45 with plastodur hybrid plastination chamber HY-100 L.

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INTRODUCTION

Anatomy is a preliminary subject in medical education which focused on basic structural organization & relationships of the various component of human body. A comprehensive understanding of anatomy provides the foundation for acquiring essential clinical skills, diagnostic abilities, and competencies required for future medical practice. Medical course relies on the cadavers for teaching and learning anatomy. This cadaver needs to preserve properly, for the cadaver preservation a different preservation method is used such as hypodermic embalming, thiel embalming & surface embalming etc.

Traditionally, cadaveric dissection is the primary method, where the direct interaction with cadavers provide medical students in depth understanding of the three-dimensional structures. Moreover, Formaldehyde (FA) solution is used as a standard preservative for cadaveric preservation. Ultimately prolonged exposure to formalin, which leads to various health hazardous symptoms such as eye irritation, lacrimation, nasal irritation, throat discomfort, headache, breathing difficulty & even nasopharyngeal carcinoma. The International Agency for Research on Cancer has also classified formaldehyde as a known human carcinogen.

Therefore, in medical education there is need to develop an alternate innovative tool for teaching and learning resources that can support faculty & students, clear orientation better than conventionally preserved specimens. Over the years, methods of

teaching & learning anatomy have begun to shift from traditional formalin-based dissection to modern technologies like plastination. ^[1,2,3,4,5]

Plastination an Modern Tool

Plastinated specimens enhance the teaching and learning experience by providing durable specimens that can be handled without gloves. Plastination technique can be broadly classified into two types: **Gross/Whole-organ plastination** and **Sheet/ Slice plastination**. **Gross plastination** involves preserving whole organs or body parts in a lifelike and anatomically accurate state. The process begins with the selection of a suitable donor body or specimen, followed by thoroughly cleaning and preparation. Fixation is carried out using a formaldehyde solution to maintain the tissue structure. The specimen is then dehydrated using acetone to remove water and lipids. Subsequently, the dehydrated specimen is immersed in a bath containing a curable polymer, such as **Plastodur Silicone S-18** or **Epoxy resin E-45**. Polymerization is then carried out, resulting in the solidification of the polymer and produce durable, lifelike plastinated specimen. Gross plastinated specimens retain their original morphology.

In contrast, **sheet plastination** involves slicing specimens into thin sections, typically **2–5 mm** in thickness. The process begins with fixation of the specimen using a formaldehyde solution, followed by slicing into thin sections using a bone and meat cutting machine. The sections are then dehydrated

using acetone to remove water and lipids. Sheet plastinated are particularly useful for studying organ systems, nerve pathways, and tissue layers, by providing a comprehensive view of internal structures. They also facilitate better differentiation of anatomical components and enhance the understanding of complex anatomical relationships by allowing cross-sectional imaging to be correlated with corresponding macroscopic structures, thereby strengthening diagnostic and clinical skills.

Consequently, plastinated specimens have emerged as a significant advancement in medical education and serve as valuable teaching and learning tools across various medical disciplines, including gross anatomy, embryology, histology, pathology, radiology and surgery

Plastination technique follows 4 basic steps fixation, dehydration, forced impregnation and curing (Hardening)

Furthermore, sheet plastinated specimens can be effectively useful to imaging techniques such as CT scans, X-rays, and MRI. [6,7,8,9,10].

Thus, plastination should be explored as an alternative educational tool for medical education. The plastodur hybrid plastination chamber and plastodur polymers were imported into India. The chamber is equipped with a hybrid system that enables all plastination procedures to be carried out smoothly.

OBJECTIVE:

To prepare the Gross & sheet plastination of cadaveric specimens and to train medical faculties in the technique of plastination.

MATERIALS AND METHODS: The cadavers donated for educational purpose to the Department of Anatomy, MGM Medical College, Kamothe, Navi Mumbai, Deemed University.

Type of study: Descriptive study

- a. **Sample size:** 30 participants
- b. **Subject area:** ICMR-DHR trainee participants medical faculties from various medical colleges
- c. **Specimen Selection:**
 - **Inclusion criteria:** Cadaveric specimens obtained from donated bodies with
 - **Exclusion criteria:** Cadaveric specimens showing gross pathological changes or having a known history of disease were excluded from the study.
- d. **Materials-**

Human Cadaveric Specimens: The following human cadaveric specimens were used for the study:

 - **Gross specimens:** Fetus, spleen & pancreas with duodenum, kidney, uterus, testis and stomach.
 - **Sheet specimens:** Kidney sections and upper limb sections.

i. Chemicals:

- Formaldehyde
 - Acetone (99.9%)
 - Hydrogen peroxide
- ii. Polymers:**

- Plastodur S-18 (Part A and Part B)
- Epoxy resin (Plastodur E-45)

iii. Equipments:

The Plastodur Hybrid Plastination Chamber and Bone and Meat Cutting Machine were funded by ICMR-DHR

e. Methods:

1. Fixation & preparation:

The specimen was immersed in a formaldehyde solution i.e. 10% formalin, after fixation, submerged or wash in running tap water to remove excess fixative solution. Then prepared specimens in final representation look & for sheet plastination of kidney & upper limb section is frozen at a very low temperature and then taken thin section 2-3mm by using bone & meat cutting machine, it has very accurate measurement of cutting thickness. [11,12]

2. Dehydration:

In this step fresh pre-cooled acetone used to remove water and lipids from the specimens, gross & sheet specimens were placed into cold acetone bath (-18°C to 25°C, with at least 99.9% purity) for 10 to 15 days. The volume of acetone should be 10 times more than the volume of the specimen. During this procedure concentration of acetone monitor by using acetometer or alcoholometer. This procedure needs to be carried

out 3 acetone baths to ensure complete dehydration, after that gross & sheet specimens placed in a room temperature acetone bath for degreasing (Defatting). Degreasing is the process of removing residual fats from the specimen before forced impregnation. It improves polymer penetration. [12,13]

3. Impregnation:

This is the crucial stage in plastination technique after the dehydration specimens were submerged with polymers such as plastodur S -18 (part A) for gross specimens & for sheet specimens UV Epoxy resin Plastodur E – 45 used. The vacuum chamber pressure was carefully adjusted. The acetone present in the tissue were start getting vaporised, and rising to the surface as bubbles. That cause the tissue to get impregnated with plastodur S -18 & Plastodur E-45. The pressure was finely adjusted and monitored frequently to maintain a steady rate of bubbles. Bubbling indicated that acetone was being extracted, so the pressure was maintained at that value until the bubbling stopped. Once the bubbles stop appearing, even with full vacuum pressure, assume that all the acetone has vaporised and impregnation is completed. The forced impregnation process needs to be slower to avoid shrinkage. Polymers are highly effective in penetrating tissues thoroughly, allowing them to reach and fill fine anatomical structures like nerves, blood vessels, and other micro-anatomical features. [13]

4. Curing:

After impregnation the last step was curing, for gross specimens- Plastodur S- 18 Part B was brushed

on the surface of the gross specimens & placed in the air tight container. For sheet specimens the section is ready for casting by using 'sandwich' method, where the thin section was 'sandwiched' between two glass plate. This glass plate is separated by a silicon tube and are held together by binder clips. The epoxy resin E-45 impregnated thin section specimen was placed in the flat chamber. Then, the E-45 resin was slowly poured in that space, used a small thick plastic sheet as a funnel. Once the E-45 resin completely filled the flat chamber, leaving no spaces or bubbles, the specimen leaved to cured, the curing process takes place under UV light. After that the flat glass chamber is removed and the extra edges of the plastinates is cut and smoothened by grinding. [14,15,16]

Fixation

Embalmed cadaver with 10% formalin

Figure.3: Flowchart showing steps of plastination technique

Preparation of questionnaire:

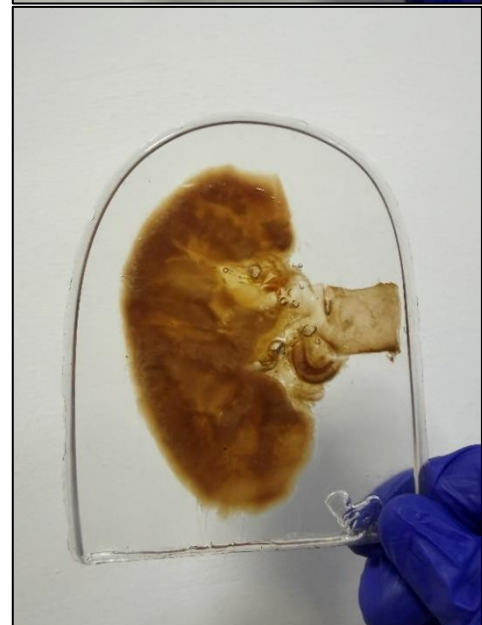
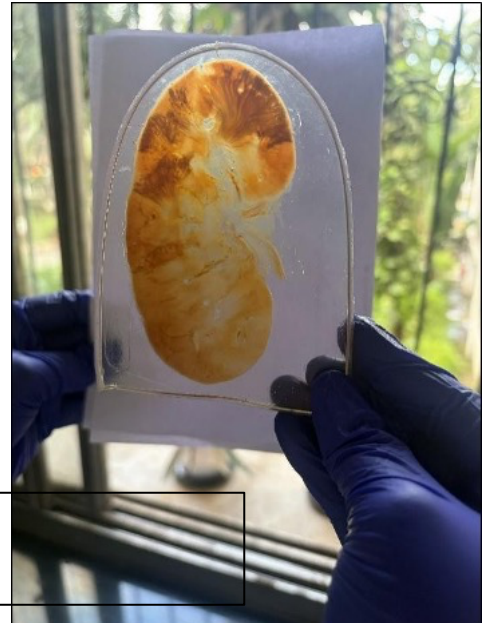
A total 10-item validated questionnaire was designed to assess participants experiences with teaching & learning anatomy using both gross & sheet plastinated specimens.

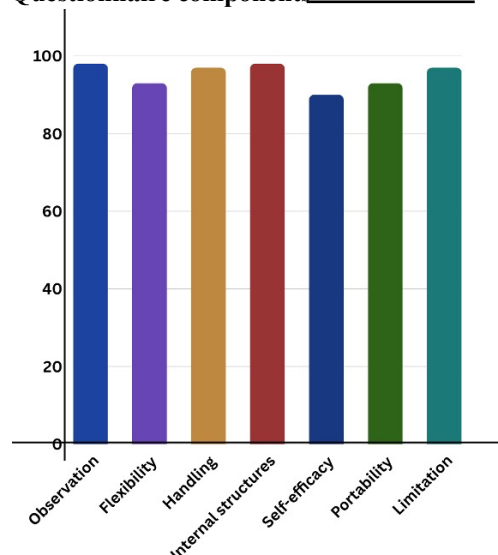
Statistical analysis:

The responses from the participants were stored in Microsoft Excel spreadsheet. The data was represented in graphical representation.

RESULT:

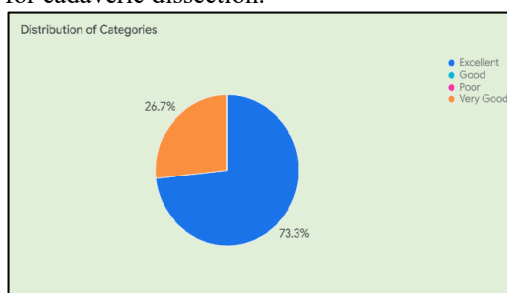
Two types of polymers plastodur S-18 & E-45 have been used for gross & sheet plastination respectively. The obtained gross plastinated were of good quality, water resistant & non-toxic. whereas, sheet plastinated specimens were thin and translucent. The plastinated specimens displayed a well-defined border.



Participants questionnaire scores**Questionnaire components**

Graph.1: The graph presents the overall feedback of participants regarding the plastinated specimen across seven components assessed through a 10-item questionnaire. The overall mean score was 94.6%, indicating a highly positive perception.

The highest score was recorded for internal structures (98%), followed by handling (97%). Observation and self-efficacy each scored 95%, indicating accurate visualization of anatomical features. Flexibility and portability scored 90% each, demonstrating support for repeated examination and learning beyond the dissection hall. The limitation score was 97%, confirming that participants recognized plastinated specimens as valuable supplementary tools but not complete replacements for cadaveric dissection.

**Annexure-I (Validated questionnaire) :****CONCLUSION:**

Plastination provides dry, durable and long-lasting anatomical specimens that facilitates a detailed study of complex structures and their three-dimensional relationships. The preserved morphology and structural integrity of plastinated specimens support a deeper understanding of anatomy while making specimen storage, handling, transportation and maintenance considerably easier than conventional wet specimens. Their durability and accessibility also allow repeated examination and use over an extended period.

Plastinated specimens serve as a versatile teaching and learning tool that can be effectively utilized beyond the conventional dissection hall, particularly

in small-group teaching, demonstrations, revision sessions and self-directed learning. Their dry and odour-free nature reduces the need for direct handling of formalin-fixed tissues and may consequently minimize routine exposure to formalin during teaching activities. Thus, plastination can complement conventional cadaveric teaching by providing a practical, reusable and learner-friendly approach to the study of complex anatomical structures.

The present study demonstrates the use of platinates with silicone S-18 & epoxy resin E-45 is promising polymer for preserving anatomical specimens thereby enhancing medical education

DISCUSSION:

Plastination is a useful method for long-term in medical educational applications. Since it has a number of benefits, durability is a major advantage. Additionally, compared to conventional preservation techniques that unpleasant chemical odour of formaldehyde. Plastinated specimens offer an eco-friendly environment for researchers and students. This technique preserving even the smallest anatomical details. Furthermore, plastination is very adaptable and can be used on thin tissue slices, individual organs or entire bodies, which makes it valuable for a medical education and scientific applications. In this process the biological specimens consist of water & fats are replaced by curable polymers such as silicone & epoxy resin. Plastinated specimens which offer a realistic specimen to teach anatomy. These specimens can be used frequently over many years without deteriorating, making them an affordable teaching tool for medical as well as other healthcare professionals. Furthermore, plastinated specimens are an exhibit in museums and science centres to raise public awareness. The plastinated specimens is helpful in surgical training as well. Plastination is utilized extensively in studies outside of the classroom.

Moreover, the process is time-consuming & involves 4 major steps, such as fixation, dehydration, forced impregnation and curing. In which forced impregnation step is most crucial, continuous monitor is required, if vacuum pressure is too high then result is shrinkage, chances of less durability and unnatural look. Controlling the vacuum pressure is most essential since prolonged periods of time then only achieved the greatest results.

Gross plastination was performed using **Plastodur Silicone S-18**, which provided good-quality and durable specimens. The silicone system consists of **Part A (silicone)** and **Part B (curing agent)**. Sheet plastination was carried out using **Plastodur Epoxy Resin E-45**. Both polymers,

along with the **Plastodur Hybrid Plastination Chamber**, were obtained from the same manufacturer, ensuring compatibility between the polymers and the processing system.^[17] Similarly, other studies were used different polymer P40 (Biodur Products GmbH, Heidelberg, Germany) polyester. In previous studies E-12 & S-10

polymer were used, some authors mentioned limitations such as the shrinkage of certain soft tissues, e.g., muscle and connective or adipose tissues. [18 - 22]

This study suggested that the resultant plastinated specimens obtained from plastodur polymer had minimal shrinkage.

LIMITATIONS:

Future studies should include nervous tissues as well as the protocol for soft tissues may vary from the gross specimens and also more participants feedback, which would have allowed for a better extrapolation of the results.

ETHICAL COMMITTEE APPROVAL:

The study was conducted in accordance with institutional **guidelines**. Ethical clearance was obtained from the Institutional Ethics Committee (IEC), Reg. No.EC/NEW/INST/2021/2255, on 17-09-2024.

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CONFLICT OF INTEREST

Authors have no conflict of interest.

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