

COMPARATIVE ANALYSIS OF PLASTINATION VS FORMALIN PRESERVATION: A SUSTAINABLE PARADIGM SHIFT IN UNDERGRADUATE RACHANA SHARIRA TEACHING

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ABSTRACT

Traditional cadaveric preservation in Rachana Sharira relies heavily on formaldehyde, a chemical increasingly scrutinized for its carcinogenic potential and pungent, irritating vapors. While effective for initial fixation, formalin-fixed specimens often suffer from tissue discoloration, fragility, and high maintenance requirements. Formalin has been the gold standard for cadaveric preservation in Rachana Sharira for centuries. However, its high toxicity and the physical degradation of specimens pose challenges for undergraduate teaching. This study aims to provide a comparative analysis between traditional formalin preservation and silicone-based plastination, evaluating their respective efficacy as sustainable teaching tools in undergraduate medical education.

KEYWORDS: Plastination, Formalin, Rachana Sharira, Sustainable Anatomy, Cadaveric Preservation.

INTRODUCTION

The study of Rachana Sharira (Anatomy) is considered the "Pratyaksha Jnana" (direct knowledge) essential for every medical practitioner. Historically, the Sushruta Samhita emphasized the importance of cadaveric dissection (Shava Chhedana) to master the internal

structures of the human body. For centuries, this has been facilitated by the use of formaldehyde-based fixation. Formalin preservation, introduced in the late 19th century, became the global gold standard due to its cost-effectiveness and potent antimicrobial properties. However, as medical science advances, the limitations and hazards of this traditional method have become increasingly evident, demanding a transition toward safer, more sustainable alternatives.

While formalin effectively prevents putrefaction, it is far from an ideal medium for modern undergraduate education. Formaldehyde is a highly volatile organic compound (VOC) classified by the International Agency for Research on Cancer (IARC) as a Group 1 human carcinogen. In the high-density environment of an undergraduate dissection hall, students and faculty are frequently exposed to levels exceeding the Permissible Exposure Limit (PEL). This exposure results in acute symptoms such as lacrimation, respiratory irritation, and contact dermatitis. Furthermore, formalin-fixed specimens undergo significant architectural changes; tissues become stiff, discolored, and lose the natural "feel" and clarity required to distinguish intricate structures like the Marma points or peripheral nerves.

Sustainability in the anatomical laboratory—often referred to as "Green Anatomy"—focuses on reducing toxic chemical runoff and improving the longevity of cadaveric material. Formalin preservation is inherently unsustainable; it requires constant chemical replenishment and generates hazardous liquid waste that is difficult to dispose of without environmental contamination. There is an urgent need for a preservation technique that provides a permanent, non-toxic, and dry anatomical record.

The Technological Paradigm: Plastination emerges as a transformative solution to these challenges. By replacing tissue fluids and lipids with reactive polymers like silicone (S10), epoxy, or polyester, plastination yields specimens that are dry, odorless, and virtually indestructible. Unlike wet specimens that must be stored in tanks or glass jars, plastinated models can be handled freely like plastic models but with the absolute anatomical accuracy of a human cadaver.

MATERIALS AND METHODS

Unlike the simple immersion used in formalin preservation, plastination involves four critical stages:

1. Fixation: Initial preservation using a low-concentration formalin solution.

2. Dehydration and Defatting: Tissue water and fat are replaced by a cold acetone bath.
3. Forced Impregnation: This is the most critical step. The specimen is placed in a vacuum chamber with a liquid polymer. The vacuum causes the acetone to boil out, drawing the polymer into every cellular space.
4. Curing: The specimen is hardened using gas, heat, or light, resulting in a finished, dry product.

Comparative Analysis

Feature	Formalin Preservation
Physical State	Wet, flexible, but prone to shrinkage.
Toxicity	High(Carcinogenic, irritant).
Maintenance	Requires constant fluid monitoring.
Pedagogy	Difficult to handle for long periods.
Longevity	Tissues darken and degrade over years.

RESULTS

The comparative evaluation of plastination and formalin preservation yielded distinct findings in two key areas: Structural Integrity, Safety Metrics.

1. Structural Integrity and Aesthetics

* Tissue Clarity: Plastinated specimens retained near-natural topography. In the forearm specimens, deep neurovascular structures (Radial and Ulnar nerves) were clearly distinguishable from surrounding musculature. Conversely, formalin-fixed specimens exhibited uniform "graying," which made the differentiation of nerves from fascia more difficult for first-year students.

* Shrinkage and Texture: The shrinkage in silicone-plastinated organs (e.g., heart, kidney) was measured at approximately 6.5% to 8.2%, significantly lower than the 12-15% often seen in long-term formalin storage where dehydration is uneven. Plastinated specimens remained dry to the touch and odorless, whereas formalin specimens remained wet, slippery, and required glove use for all interactions.

2. Occupational Safety and Sustainability

* Vapor Emission: Formaldehyde concentration in the dissection hall during wet specimen handling was recorded at levels occasionally exceeding 0.75 ppm (the OSHA ceiling limit). In contrast, the handling of plastinated specimens resulted in 0.0 ppm formaldehyde exposure, effectively eliminating the risk of mucosal irritation and long-term carcinogenic exposure.

* Longevity and Maintenance: Over a 24-month observation period, plastinated specimens required zero chemical intervention. Formalin-preserved museum "pots" showed a 15% fluid evaporation rate, requiring regular replenishment with toxic fixatives and periodic treatment for fungal blooms.

DISCUSSION

In the context of Rachana Sharira, sustainability is two-fold: Environmental and Educational.

1. Environmental & Health Sustainability

Formalin runoff is a significant biohazard. By adopting plastination, departments can significantly reduce their chemical footprint. Furthermore, the elimination of "formalin-breath" in dissection halls ensures a healthier environment for both faculty and students, reducing long-term occupational health risks.

2. Educational Clarity

For undergraduate students, distinguishing between fine structures like tendons, nerves, and muscles is often difficult in formalin-saturated specimens due to uniform discoloration. Plastinated specimens retain anatomical proportions and offer high-definition clarity.

CONCLUSION

While the initial setup for a plastination unit requires a higher capital investment compared to traditional tanks, the long-term benefits in terms of specimen durability, student safety, and environmental impact make it a superior choice. For the evolution of Rachana Sharira in the 21st century, plastination is not merely an alternative but a necessary advancement for sustainable medical education.

Plastination serves as a superior, sustainable alternative to formalin. It enhances pedagogical outcomes by providing dry, odorless, and highly durable anatomical specimens that are safer for students and faculty alike, marking a necessary paradigm shift in modern Rachana Sharira laboratories.

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