Review Article

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PLASTINATION: AN OVERVIEW OF THE REVOLUTIONARY TECHNIQUE IN PRESERVING BIOLOGICAL SPECIMENS FOR EDUCATION AND RESEARCH

Sadhana Sharma [1], Akhila Rajan [1]*, Shyoram Sharma [2], Rakesh Kumar Sharma [2]

[1] PG Scholar, PG Department of Rachana Sharir, Post Graduate Institute of Ayurved, Dr. Sarvepalli Radhakrishnan Rajasthan Ayurved University, Jodhpur, Rajasthan, India

[2] Associate Professor, PG Department of Rachana Sharir, Post Graduate Institute of Ayurved, Dr. Sarvepalli Radhakrishnan Rajasthan Ayurved University, Jodhpur, Rajasthan, India

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***Corresponding author**
E-mail: rajanakhila32@gmail.com

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ABSTRACT

Plastination is a novel technique for biological specimen preservation. Plastination substitutes curable polymers for water and lipids in tissues, making specimens long-lasting, non-toxic, and odorless in contrast to conventional preservation methods, which frequently pose health risks and need upkeep. Fixation, dehydration, forced impregnation, and curing are some of the steps in the process; modifications such as the S10 technique and polyester polymers are used to meet specific needs. Clear anatomical visualization provided by plastinated specimens is advantageous for medical research, teaching, and public displays. However, issues like exorbitant expenses, intricate technicalities, and moral dilemmas need to be resolved. Its influence on science and education can be increased and its accessibility improved with more study and improvement.

Keywords Plastination, Preservation, Anatomy, Rachana sharir, Ayurveda

INTRODUCTION

Decay is a vital process in nature but a barrier to morphological studies, teaching, and research. [1]This is especially true for biological specimens, which shrink significantly when exposed to ambient air . Finding suitable preservation techniques has therefore always been the aim. The two most popular methods for preserving specimens are enclosing them in glass or Perspex "pots" or suspending them in fixatives such formalin-based solution as open, wet preparations. Because of their disagreeable smells and the formalin fumes they exude that cause skin and eye discomfort; open specimens are unpleasant to work with. Students are likewise reluctant to handle or inspect these specimens.[2]

Although specimens kept in glass jars or Perspex "pots" may be able to overcome these issues, they still need to be handled carefully and frequently in order to prevent the fluid from getting murky and hiding important information. Furthermore, there is little colour preservation, and highlighting details is made more difficult by the parallax error brought on by the spatial distances from the pot surface. Various considerations, together with the health risks linked to formalin restrict the applicability of various specimen preservation techniques. Body part plastination is becoming more and more significant for the long-term maintenance of tissue and anatomical learning. This position paper's objectives are to highlight the value of plastination and go over certain issues. Intrinsic to plastination as a superb technique for tissue preservation over an extended length of time. There are several plastination techniques, each with pros and cons. The best technique for preserving tissues, entire bodies, or individual body parts over an extended period of time is Plastination, also known as forced polymer impregnation. Getting potential donors' written and informed consent is crucial in light of this.[3]

Nowadays, plastination treatments come in a variety of forms. A shortened, modified plastination process developed by the Department of Anatomy has shown to be economical, require little in the way of infrastructure, and yield exceptionally well-preserved specimens.[4]

Dr. Gunther von Hagens first presented the bodily tissue preservation technology known as "plastination" to the medical community in 1977. It has undergone significant development and has several different stages of processing. These procedures substitute the water and lipids in biological tissues with curable polymers, primarily silicone, epoxy, and polyester, which harden to produce durable, odourless, and natural-looking specimens.[5]

Background

Gunther Von Hagens created the plastination process in Germany in 1977. After experimenting with a variety of polymers on numerous tissues and organs, he created the fundamentals of the plastination process, which he patented between 1977 and 1982. The S10 technique, created by Gunther Von Hagens (1986–1987), is the gold standard for plastinating organs, tiny tissues, the entire body, and portions of the brain. It has received approbation from numerous researchers.[6] The most delicate specimens with little flexibility and excellent surface detail are produced by this procedure. Formalin-fixed specimens were dehydrated in acetone at -20°C for three weeks, and then they were submerged in an S10/S3 (ratio 100:1) mixture at -20°C for one week. Subsequently, forced impregnation was carried out under vacuum at −20°C, and S6 vapors were used for gas curing.[7]

Later, polyester polymers like P35 and P40 were used for plastination. Brain slices with unmatched beauty, clarity, and good white and gray matter definition were obtained from the P35 [8], which was presented first. Since P40 was released later, a shorter and less complicated method is required. Several writers

have developed variations of these methods that produce positive outcomes.[9]

Key milestones in the development of plastination

Plastination was created in 1977 by Dr. Gunther von Hagens while working on a study of human kidneys, and on January 10 of that year, he held the first plastinate in his hands, marking the development of plastination as a preservation method. In 1978, at Heidelberg University's Anatomical Institute, Dr. von Hagens began refining his plastination technique, leading to new discoveries such as the plastination of thin, translucent slices of bodies and brains, with numerous patents being issued in other nations, particularly the USA. To market plastination supplies and equipment globally, Dr. von Hagens established BIODUR in 1980, introducing the technique to academic institutions and gaining recognition at conferences. The International Society for Plastination (ISP) was founded in 1982 following the first Conference on Plastination in Texas, and since then, international plastination conferences have been held every two years. In 1993, Dr. von Hagens founded the Institute for Plastination in Heidelberg to oversee the method's expansion beyond academic settings as it underwent significant evolution. Transitioning from sensation to standard, plastination became a widely accepted and standardized scientific procedure in the field of anatomy, with over 400 laboratories in 40 countries utilizing it for academic research. [10]

Plastination Technique

It categorised based on the kind of final product or the kind of resin employed during the plastination process. Over the previous 30 years, a large number of resins have been studied for possible use in the plastination process, which has led to the development and discovery of numerous plastination processes, each with unique benefits and drawbacks. Nonetheless, silicone, epoxy resin, and polyester are the most often utilised plastination resins. [11]

Depending on the type of specimen and material employed, there are two different procedure types .

Steps for the two types of plastination in general

Chemicals required

- Acetone
- Methylene chloride
- Silicone polymer
- Catalyst to prepare silicon molecules
- Chain extenders cross linkers for silicone molecules

Apparatus for fixation.

Table 1: Stages of plastination techniques [12]

Name of process	Timming	Method
Fixation (Embalming)	About three to four hours	The arteries are filled with formaldehyde or another preservation solution to kill bacteria and stop tissue deterioration. Stabilizing the tissues and getting them ready for the next steps depend on this first step.
Dissection	500–1,000 hours of work, depending on how complicated the specimen is	Individual anatomical structures and elements are exposed and prepared by carefully removing skin, fatty tissues, and connective tissues. Expert anatomists who can painstakingly dissect the body without endangering the underlying structures are needed for this stage.
Dehydration	Approximately four months	In a frozen state, soluble lipids and water in the tissues dissolve and are replaced by acetone. This is a crucial step in getting the specimen completely dry so that polymers can be impregnated in it.
Forced Impregnation	Around 2 months	The specimen that has been dehydrated is immersed in a liquid polymer bath, such as epoxy resin, silicone rubber, or polyester. Every cell is penetrated and preserved because the acetone evaporates when a vacuum is applied, allowing the cells to absorb the liquid polymer.
Positioning	approximately two and half months	Wires, needles, clamps, and foam blocks are used to strategically align and fix the specimen while it is still flexible. To guarantee that the finished plastinate faithfully captures the body's natural posture and architecture, this phase calls for specialist anatomical understanding as well as aesthetic considerations.
Curing (Hardening)	Around1.5 to 2 months	Depending on the polymer employed, heat, light, or gas can be utilized to solidify the specimen in place. By shielding the plastinate from deterioration and breakdown, this last stage produces a robust specimen that keeps the majority of its original characteristics, such as exact weight.

DISCUSSION

Plastination is a useful method for long-term educational applications since it has a number of benefits. Durability is a major advantage since plastinated specimens don't deteriorate over time. Additionally, compared to conventional preservation techniques that employ noxious and unpleasant chemicals like formaldehyde, plastinated specimens offer a friendlier environment for researchers and students. Clarity is another benefit since the method accurately visualizes structures by 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 variety of educational and scientific applications.

Plastination has been particularly useful in the study of anatomy and the medical sciences in both research and education. The process produces dry, odorless, long-lasting specimens that require little care by substituting curable polymers for human fluids. Plastinated specimens, which offer a realistic and detailed substitute for cadavers, are widely used in medical schools to teach anatomy, pathology, and surgical methods. These specimens can be used frequently over many years without deteriorating, making them an affordable teaching tool for medical and nursing students as well as other healthcare professionals. Furthermore, plastinated bodies are frequently on exhibit in museums and science centers to raise public awareness of medical issues and to teach people about human anatomy and health. Additionally, the approach is helpful in surgical training since it allows trainees to conduct procedures on plastinated specimens in a risk-free setting, giving them crucial practical experience.

Plastination is utilized extensively in studies outside of the classroom. Plastinated specimens are examined by researchers to investigate anatomical variances, the course of diseases, and the

effects of different treatments on tissues. Accurate and repeatable findings are guaranteed by the high degree of preservation. While comparative anatomy benefits from the ability to retain animal specimens for cross-species comparisons, supporting veterinary and evolutionary study, anatomical studies examine plastinated specimens for in-depth structural analysis. Plastination also makes pathological research easier by allowing scientists to maintain afflicted specimens for closer examination, which advances our knowledge of disease mechanisms and the creation of treatments.

Plastination has several drawbacks that need more study and advancement despite its many advantages. Deep freezers, vacuum chambers, gas curing rooms, and stainless-steel containers are among the specialist equipment needed for this intricate and expensive operation. Furthermore, the process is time-consuming and involves several steps, such as fixation, dehydration, impregnation, and curing. Another issue is the cost of materials because plastination usually involves the use of pricey polymers like polyester, epoxy, and silicone rubber.

There are also a number of technical difficulties. Discoloration may occur in specimens that have been preserved for more than 100 days, obscuring anatomical details and diminishing their teaching value. Furthermore, dehydration processes alter the specimens' pliability, which can occasionally result in shrinkage and an unnatural look. Controlling the length of the impregnation is essential since prolonged periods of time may result in color loss, while shorter periods (less than 10 days) produce the greatest results.

Another problem is safety, especially since acetone is used in the dehydration process, which releases flammable fumes. In order to avoid ignition threats, strict measures must be taken, which makes lab setup and maintenance more difficult. Lastly, despite its benefits, plastination has not gained much traction in some fields, such oral pathology, suggesting that its wider use may be limited.

Plastination is a groundbreaking method in anatomical research and education, but its effectiveness and accessibility across a range of academic fields could be further increased by tackling these issues through the creation of substitute materials, process optimization, and improved safety precautions.

CONCLUSION

Plastination has proven to be a valuable method for long-term educational and research applications in anatomical sciences. Its durability, clarity, and adaptability make it an effective tool for medical education, surgical training, and anatomical research. The ability to preserve specimens without the use of hazardous chemicals enhances the learning environment for students and researchers while ensuring long-lasting anatomical models. Additionally, plastination supports various scientific disciplines, including pathology, veterinary medicine, and evolutionary biology, by providing high-quality specimens for analysis.

However, despite its advantages, plastination presents several challenges that require further research and innovation. High costs, complex procedures, and technical issues such as discoloration, shrinkage, and safety concerns with flammable chemicals limit its widespread adoption. Addressing these challenges through process optimization, cost-effective materials, and improved safety protocols could enhance its accessibility and usability across a broader range of academic and scientific fields. With continued advancements, plastination will remain a crucial tool in anatomical education and research, expanding its applications and benefits for future generations.

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