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RESEARCH ARTICLE

The Use of Make-Shift Plastination Procedures to Produce a Plastinate of the Heart

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Abstract

Plastination is one of the most recent and most ideal preservation methods which is used for preserving organic tissue commonly used in anatomy, to produce durable anatomical specimens of the entire body or body parts consisting of the forced impregnation, in a vacuum, of biological specimens with reactive polymers. The present study aimed to use make-shift equipments for plastination procedures to produce a plastinate of the heart that is dry, nontoxic, odourless and durable using a modified Silicone S10 technique. The chemicals used were; BIODUR® Silicone S10, BIODUR® Hardener S3, BIODUR® Hardener S6 Acetone, Formaldehyde and distilled water. The equipment used were Vacuum pump (®VALUE VE115N), Special Freezer for Plastination, Dehydration Container, Cotton-wool, Acetometer 0% - 100%, dissecting set, weighing balance, Gas Curing Unit, Vertical thermostat and Vacuum chamber (Made of deep stainless-steel bucket, a transparent flat glass). Silicone S10 + S3 technique was used in the plastination process. The overall structure of the plastinated organ was intact and fully impregnated with the Silicone S10 polymer giving it a plastic look and feel. There was no disorientation of the major great vessels of the plastinated heart. There was however minor discoloration of the tissues due to the removal of all fluids and replacement with plastic polymers.

Keywords: Plastination; Plastinate; Heart; Silicone S10; Make-shift Technique

Introduction

The desire of mankind to preserve organic tissue is as old as humanity. Different embalming methods have been developed in the past, but none of them could be defined as perfect. Plastination is one of the most recent and most ideal preservation methods. Plastination is a method of preserving organic tissue commonly used in anatomy, to produce durable anatomical specimens of the entire body or body parts consisting of the forced impregnation, in a vacuum, of biological specimens with reactive polymers. [1-3] Many applications of plastinated tissues, organs and sections of bodies, prepared by the standard techniques of plastination, have been cited and have been recognized as perfect tools for direct or indirect instructional purposes like teaching students. The materials for preparing the specimens are safe and less hazardous like S10 Silicone, S6 gas cure and S3 catalyst. [4-9]

Over the years, formalin-fixed anatomical specimen has been widely used for anatomical pedagogy in various medical institutions. This formalin technique has over time become hazardous, difficult to handle and archaic, hence raising concerns as to which method is best to solve the problem of either the hazardous nature of formalin-fixed cadavers or the shortage of cadaveric specimen as a whole. [10-12] However, plastination can provide an alternative that is biosecure, dry, odorless, and easy to handle. Plastination method of preservation has over time proved to be the best solution there is so far having showed the propensity to solve a wide range of cadaver or specimen related issues in various areas of specialization ranging from Anatomy, Medicine, Pathology, Veterinary Medicine and Animal Science [10,12-14].

A controversy exists about the ideal method of teaching anatomy. There are various techniques employed worldwide in anatomy education which includes; lectures, cadaver dissection by students, inspection of prosected specimens, use of models, teaching of living and radiologic anatomy, and computer-based learning (virtual reality, augmented reality and three-dimensional (3D) reconstruction). [15-17] According to Estai and Bunt, (2016) [15] in the critical review for anatomy teaching practices, there is no a single method for anatomy education and a combination of teaching modalities is required. Among them, the cadaver dissection is for now an irreplaceable teaching tool for anatomy learning. [18] Nevertheless, post-mortem body donation nowadays has significantly diminished, while concerns have also been raised about the difficulty of maintaining cadaver. [8,19-20] For more than two decades the technique of plastination, introduced by Von Hagens (1977),[8] comprising the replacement of water and lipids by curable plastic polymers became a useful tool for tissues preservation. [21] The innovative techniques of plastination have been used for the production of transparent body slices, and detailed demonstration of anatomical structures. [22-23] Plastination can fill the cadaver shortage gap in countries that are deficient in this regard and be an additional tool for teaching anatomy. Plastination is playing an important role in the long-term preservation of tissues and aiding in anatomical teaching. Several studies show that plastinated specimens enrich the teaching process and the learning outcome is higher. [1,21,24] The use of plastinated specimens has been found to be beneficial for the understanding of radiographic techniques such as echography, computed tomography or magnetic resonance imaging. [8,24,25]

The present study aimed to use make-shift plastination procedures to produce a plastinate of the heart that is dry, nontoxic, odourless and durable using Silicone S10 technique in a bid to solve organs for study shortage and create a framework for plastination in Nigeria.

Methodology

The present study employed the use of a modified Silicone S10 + S3 technique. The study employed the standard Biodur silicone technique however we didn't have the standard equipments for the procedure like vacuum chamber and cooling system hence we had to use makeshift equipments for the procedure. The chemicals used were; BIODUR® Silicone S10, BIODUR® Hardener S3, BIODUR® Hardener S6 Acetone, Formaldehyde and distilled water as prescribed by Von Hagens, (1987) [8] and Henry (1993) [4]. Vacuum pump (®VALUE VE115N), Special Freezer for Plastination, Dehydration Container, Cotton-wool, Acetometer 0% - 100%, dissecting set, weighing balance, Gas Curing Unit, Vertical thermostat and Vacuum chamber as shown on figure 1 (Made of deep stainless-steel bucket, a transparent flat glass).

Figure 1: A set-up of plastinating apparatus

Organ Preparation and Fixation

The heart was cut open from the apex to enable proper visualization of the internal walls of the heart and to also enable removal of clotted blood. Before fixing, cotton wool was placed in-between the atria and the ventricle to prevent it from collapsing. The heart was placed in a container of 10% neutral buffered formalin solution and fixed for a period of three (3) days. [4-9]

Figure 2A: Showing grossing and preparation of the Organ before fixation

Figure 2B: showing the organ after fixation for 3 days.

Dehydration

Dehydration was carried out in order to remove water content from the tissues. Freezing temperature of the acetone at -25°C was required to minimize the rate of tissue shrinkage. The dehydration process was carried out with the volume of cold acetone to tissue being 5:1. The specimen was dehydrated for 3 weeks using three changes of acetone at one-week intervals. [4-9]

Forced Impregnation in a Vacuum Chamber

The two grades of Silicone (Biodur S10 + S3) were homogeneously mixed together. The heart was placed in the Silicone resin (Biodur S10 + S3) in the locally constructed Vacuum Chamber. The vacuum pump was connected to a power source. The impregnation process was done for a week. When the vacuum was near 0 mm Hg and bubbles were seen on the surface of the polymer, the vacuum pump was turned off. The appearance of bubbles signified that the specimen has been fully impregnated. The specimen was removed from the vacuum chamber and allowed to drain at room temperature. [4-9]

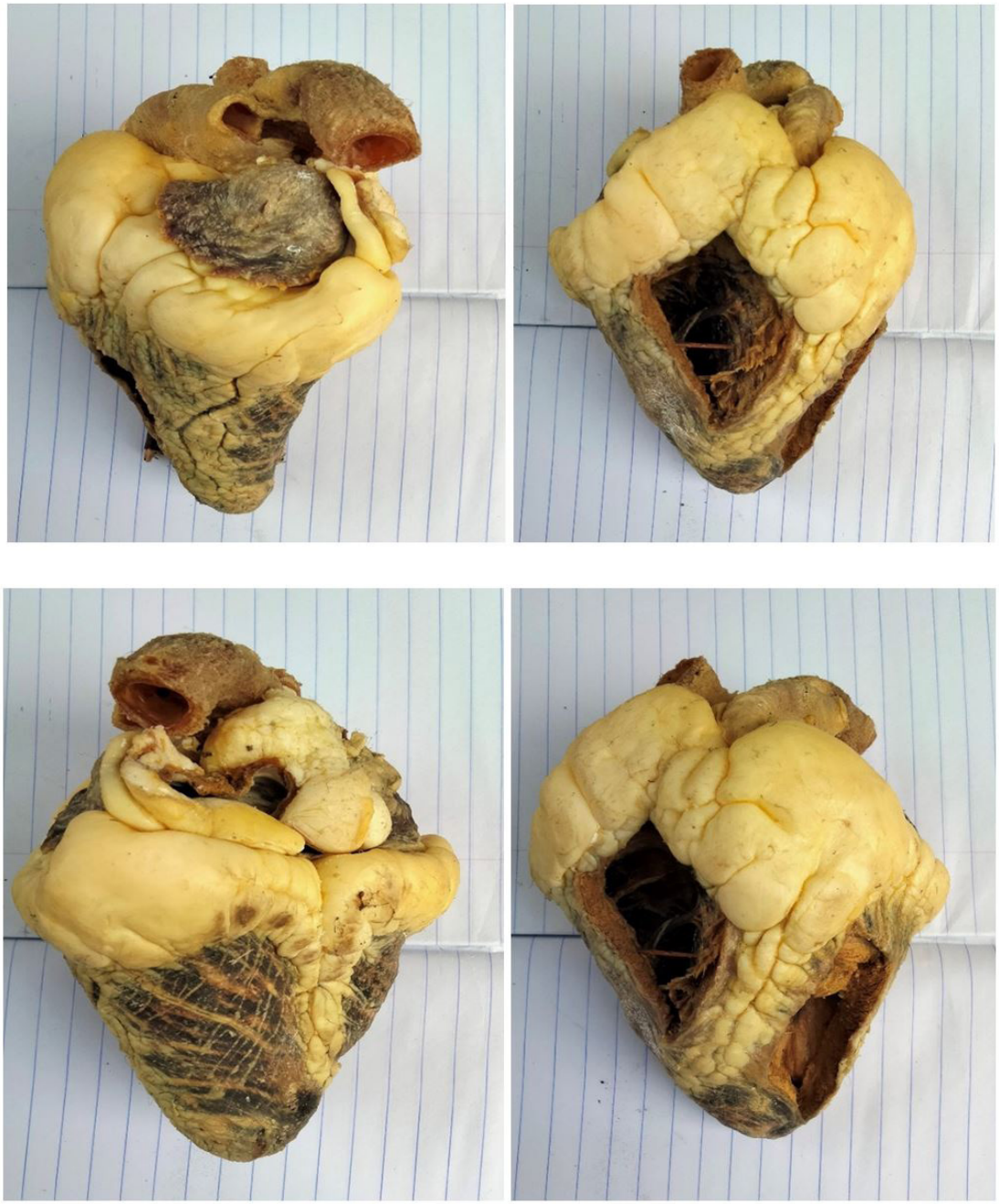
Gas Curing

The excess mixture of BIODUR S10 + S3 was drained from the specimen by rotating the heart several times and repeated cleaned using cotton wool. After the heart was drained and cleaned, it was placed in a vertical thermostat. The BIODUR S6 which is the curing agent was poured into an open container and is equally placed in the thermostat, with Silica gel which served as a desiccant. Excess dripping BIODUR S10 + S3 were wiped off. This process lasted for the period of six (6) weeks. [4-9]

Figure 3: Showing an improvised curing stage using an oven as a curing chamber with specimen neatly arranged. It also contains BIODIUR S6 as the curing gas and potassium acetate for dehydrating

Result

The lack of standard equipments was the major challenge in this research however we were able to achieve the aim of the project using makeshift equipments which did not significantly affect the output of the plastinate. The overall structure of the plastinated organ was intact and fully impregnated with the Silicone S10 polymer giving it a plastic-like look and feel. There was no disorientation of the major great vessels of the plastinated heart. There was however minor discoloration of the tissues due to the removal of all fluids and replacement with plastic polymers.



Discussion

In teaching and learning anatomy, books do not deliver structures in three dimensions 3D, so complex topography is difficult to understand. [26,27] Plastination is emerging as a new approach to teach anatomy. As an innovative preservation method, it does, however, make it possible to create completely new types of specimens. When the polymers harden, for instance, muscles that would ordinarily be slack now can provide sup- port, allowing the body to be displayed in a variety of unusual poses, either in its entirety or in various stages of anatomical dissection. Plastinated specimens have been valued by students as a high-quality resource during their anatomical studies, confirming the importance of using cadaveric material in anatomical education. [28] They provide the opportunity to learn basic anatomy in a short period of time, suggesting the adequacy of this modality for the early stages of anatomical leaning, especially when taking constraints of time and the availability of other resources into account. [6-11]

Currently, plastination is emerging as one of the most important anatomical preservation techniques due to its ability of preserving bodies and organs for an indefinite period in a dry and bio-secure form and also preserving the morphological characteristics of the tissues. However, the weight loss of the samples is also a crucial factor to consider, perhaps becoming one of its few disadvantages. [28-31]

From the present study, the use of BIODUR (S10, S3 and S6) seems to be the easiest as much expertise is not required. After fixation there was a slight discolouration of the specimen. After dehydration, there was a significant loss of weight and further discolouration of the specimen. The rate of tissue shrinkage was greatly minimal as a result of dehydrating in acetone bath with temperature rang of -25°C.

It is alleged that the Silicone S10 technique is the standard technique and most frequently used method in plastination and the most common failures associated with it are shrinkage, weight loss and change of colour. [32,33] The other types of failures are visible defects, which includes deformation, crained surface, damaged arteries and nerves or roughen surface of specimen. The spots on organ surface are also common defects. Based on morphological examination of the specimen it shows that the causes of this defects are: inappropriate temperature of reaction, mixture, specimens with colour changes, usage of badly fixed specimens or the specimens with dry spots on surface testifying untimely drying of material.

Conclusion

At the end of the twelve (12) weeks of plastination processes, the outcome of the specimen was as expected with desirable results. Plastination portrays great potentials in all fields of training, research and also public culture and instruction throughout the world. Since, it is a new, fast and hazardless technique and shows a possibility to be available to many departments of anatomy.

The present study employed the use of make-shift equipments such as an improvised cooling system and an improvised vacuum chamber constructed locally with stainless steel bucket and and a glass cover. With the use of these make shift tools, the final product came out fully plastinated, suggesting that plastination is still possible with limited equipment. Plastination can serve as a good replacement for formalin-based preservation as there are no health hazards associated with Silicone plastinates. Lots of efforts should be targeted towards developing fast and cost-effective techniques of plastination in order to increase the supply of study specimens in anatomy.

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Conflict of Interest

The authors declare no conflict of interest.

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