

**REVIEW ARTICLE**DOI: <https://doi.org/10.3329/mediscope.v10i1.65409>**Plastination: A Novel Way of Preservation of Cadaveric Specimens for Teaching and Learning Human Anatomy****\*ASM Nurunnabi<sup>1</sup>, A Alim<sup>2</sup>, MM Hoque<sup>3</sup>, S Askary<sup>4</sup>****Abstract**

Plastination is a preservation method of anatomical specimens, which can be used for long-term educational purposes both in basic and clinical sciences. Dr. Gunther von Hagens first developed this technique in 1977 in Heidelberg, Germany. There are several plastination methods that are currently used in different countries. Room-temperature silicone plastination using 'North Carolina technique' is assumed as the best suited for our institutions considering our country's climate and feasibility in terms of limited resources. In general, plastination methods involve four stages: i) fixation and specimen preparation; ii) dehydration and defatting; iii) plastic permeation or force impregnation by plastic material; and iv) hardening or curing. Fixation involves addition of formalin to the specimen for preventing decay and bacterial growth. Then dehydration is done by submerging the specimen in acetone baths. Thereafter, the specimen is kept in a vacuum chamber, where plastic permeation or forced impregnation occurs. Polymers penetrate the tissues of the specimen while removing acetone. After leaving the specimen in an airtight chamber maintaining a specific temperature, hardening or curing process follows. Plastination technique has several advantages like making cadaveric specimens easy to handle, easy storage of viscera, prolonged preservation, odourless, dry, non-irritant, nontoxic presentation and ability to present more anatomical details than ever before. Some important drawbacks are that the process is very costly, time consuming, limited size of the impregnation chamber, health and environmental hazards of the chemicals used. Plastination seems to have a great future in all fields of teaching, training and research not only in anatomy education but also in other disciplines in medical, biomedical, veterinary and health science institutions across the globe. Plastinates have opened several new windows to the world of anatomical sciences.

**Keywords:** Plastination, Cadaveric specimens, Viscera preservation, Anatomy teaching and Learning, Medical education.

**Introduction**

The term 'plastination' originates from a Greek word 'plassein' which means 'to shape' or 'to form'. Plastination is a preservation procedure of anatomical specimens that are used for long-term

in educational purposes both in basic and clinical sciences.<sup>1</sup> The basic idea of plastination is to prevent decomposition of the specimen by replacing its biological fluid e.g., water and fat with certain plastic/resin materials.<sup>2-4</sup> Plastination technique was first developed by Dr. Gunther von

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Hagens in 1977. Then he established the Institute for Plastination at Heidelberg in 1993. He exhibited his products in the National Science Museum in Tokyo in 1995 after being invited by the Japanese Anatomical Society. Thereafter, the first Body Worlds exhibition took place in Mannheim, Germany in 1997. Since then, the Body Worlds has been exhibiting plastinated specimens in museums across the globe.<sup>1,2</sup> Besides, he also established a company named Biodur®, which supplies wide variety of materials required for plastination to many of the medical institutions around the world.<sup>2</sup>

In teaching and learning anatomy, dissection and observation of cadaver and gross cadaveric specimens are traditional and time-honoured tools being used for centuries.<sup>5</sup> However, there is an utmost need of preserving the cadavers from ongoing natural processes of decomposition and putrefaction.<sup>6</sup> To accomplish the demand, the conversion of preservation techniques came through a long process over decades ranging from embalming to mummification to cryopreservation.<sup>6-8</sup> In course of time, upgrading the knowledge from the drawbacks of previous preservation techniques led to the exploration of modern plastination procedure.<sup>7,9</sup>

This review aims to describe the methods of plastination that is suitable for medical institutions considering our country's climate and feasibility in terms of limited resources and some of the potential advantages and drawbacks of plastinated specimens in teaching and learning of human anatomy.

### Steps of Plastination

In different medical institutions, the Department of Anatomy have laboratories that utilize plastination procedures to preserve different viscera or specimens for future educational purposes. There are several different plastination methods that are currently used.<sup>3-6,9-12</sup> The technique and substances used for plastination are results of upgradation within the basic technique itself. We will discuss the procedure of 'Room-Temperature Silicone

Plastination' using 'North Carolina technique'<sup>10</sup>, which is assumed to be best suited for our institutions considering our country's climate and feasibility in terms of resources. However, in general, plastination methods involve four stages<sup>10-12</sup> (as shown in Figure 01):

- i) Fixation (embalming) or specimen preparation;
- ii) Dehydration and defatting;
- iii) Plastic permeation or force impregnation of plastic materials; and
- iv) Hardening or curing.

#### **i) Fixation (embalming) and specimen preparation:**

The viscera must be in a good shape and the hollowness of the inner chambers/cavities should be intact and empty before plastination starts. The first step is preventing decay of the internal structures of the viscera by formalin infusion. Instead of being submerged in formalin solution, the tissue is directly injected with formalin, as it replaces water; it also prevents bacterial growth in the specimen. This process takes about 3-4 hours.<sup>2,4,12</sup> However, the formalin must be thoroughly washed out when plastination starts.<sup>10</sup> All specimens are typically rinsed with tap water for 2-4 hours before beginning dehydration. The visible and inner arteries and veins can be injected with latex at this point to emphasize the anatomical contour. The arteries and veins in the viscera are typically injected with red and blue latex respectively. To achieve a better result, all the vessels are injected using a venogram balloon catheter.<sup>10-12</sup>

**ii) Dehydration and defatting:** In this step, the biological fluid within the specimen (e.g., water and fat) is replaced by acetone through prolonged exposure and diffusion. Dehydration takes place at  $-25^{\circ}\text{C}$  and defatting takes place at room temperature. More specifically, a specimen is prepared following above-mentioned procedure and then placed in 90-100% acetone bath at  $-25^{\circ}\text{C}$ . These 90-100% baths are repeated until the purity of acetone reaches above 95% at equilibrium. Since fat does not plastinate well, most of the fat must be removed in this step. Defatting procedure starts by placing the

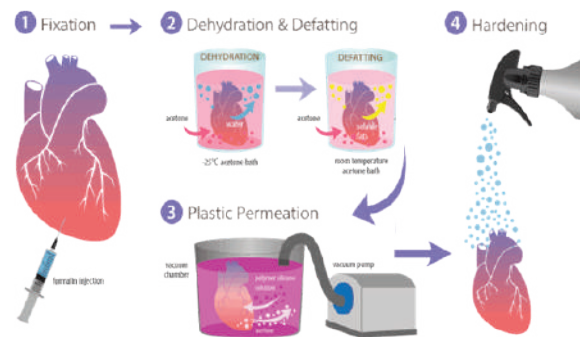
specimen in a 99-100% acetone bath at room temperature. These baths are repeated until the acetone purity reaches above 98% at equilibrium. Defatting is complete when the acetone colour becomes clear; however, fat may remain in the specimen which is very negligible in amount.<sup>10-12</sup>

### iii) Plastic permeation or forced impregnation

**of plastic materials:** The next step is forced impregnation, where a liquid polymer substance (e.g., silicone rubber, polyester or epoxy resin) replaces acetone within the tissue. A given specimen embedded with acetone is placed in a vacuum chamber filled with a 10:1 mixture of NCS10 silicone polymer and its NCr20 crosslinker (North Carolina products).<sup>10</sup> Acetone has a higher vapor pressure than the polymer mixture; hence, when vacuum is applied, acetone will evaporate sparing the polymer mixture. Then, the polymer will get sucked into the vacancies within the specimen.<sup>10</sup> The operations of the vacuum chamber system is very crucial. Once the specimen has equilibrated with the polymer mixture overnight, the chamber is sealed, and the vacuum is applied. By closing the needle valve connected to vacuum chamber, the vacuum pressure is controlled gradually lowered, which helps to maintain rapid bubble formation within the chamber. The dry ice acetone trap is used for condensation and trapping acetone before it reaches the vacuum pump. When bubble formation ceases, the needle valves are closed, and the vacuum pressure is less than 5mmHg, it is considered that acetone has been removed fully from the specimen. When impregnation is complete, the pump is turned off and the specimen is brought to the atmospheric pressure.<sup>10-12</sup> This process lasts 2-5 weeks.<sup>2,10,13</sup> After vacuum impregnation, the specimen is still flexible and can be positioned as desired. Every single anatomical structure is properly aligned and fixed with the help of wires, needles, clamps, and foam blocks.<sup>10,13,14</sup> Positioning of these specimens requires a lot of anatomical knowledge and a defined sense of aesthetics.<sup>13,14</sup>

**iv) Hardening/curing:** In this step, a curing agent is applied to the specimen (depending on the

polymer used, this is done with gas, light, or heat). Curing protects plastinated products against decomposition and decay.<sup>2,10-12</sup> The curing agent catalyzes reactions between the polymer and its cross-linker, which allows the specimen to harden. The specimens taken out from the vacuum chamber. They are drained and wiped down to remove any excess polymer.<sup>10-12</sup> It may be mentioned that excess silicone is drained first at  $-20^{\circ}\text{C}$  and then at room temperature, and also wiped off with gauze and paper towels before and during the early phase of curing with S6 cross-linker.<sup>13</sup> The specimens are left to dry for a few days to allow for some chain extension of the polymer. The NCr30 catalyst (North Carolina product) is then applied to the specimen with a spray bottle or paintbrush.<sup>10</sup> The specimen is then wrapped in plastic wrap. The catalyst application and subsequent wrapping are repeated daily until the specimen is fully cured.<sup>10-12</sup> The result yields durable plastinates that retain most of their original properties, including precise weight.<sup>2</sup> This process takes 6-8 weeks.<sup>2,10,13</sup>



**Figure 01: Plastination technique (Source: Eastern Virginia Medical School, USA, 2021).<sup>12</sup>**

### Types of Plastination

On the basis of size, shape and nature of tissue, there are three types of plastination: whole body/organ plastination, luminal cast plastination and sheet plastination.

**Whole organ or body plastination:** In this method, silicone (S10) and polypropylene resins

are used. Using this technique, whole of the structure or organ, and its relationships can be preserved.<sup>9,13</sup>

**Luminal cast plastination:** It is usually done for hollow organs like lungs, stomach, intestine, ventricles of brain, heart and kidneys. Beautiful and precise bronchial or arterial patterns can be seen by this technique.<sup>13,14</sup>

**Sheet plastination:** In this method, thin transparent or thick opaque sections of body or an organ are preserved. These sheets are portable and shows cross sections of organs in various planes, which resemble CT or MRI scan sections. Thin sections (1-2mm) of organs are very similar to routine histology slides. Polymers such as epoxy (E12), polyester (P40) etc. are used for making sheet plastinates.<sup>9,15-17</sup>

### Advantages

In general, plastination technique has several advantages. It makes cadaver and specimens easy to handle, easy to store, odourless, dry, non-irritant, nontoxic, preserves for a longer duration (up to 40 years) and overall, gives more anatomical details when we use it in teaching and learning.<sup>2,5,14-16,18-23</sup> Its one big advantage is that it is possible to move between the macroscopic specimen and the microscopic histology slides to compare the structure in detail.<sup>2,22</sup> Moreover, plastinated specimens have a better ability to reflect anatomical variations of different organs and congenital malformation.<sup>2,19,20</sup> To date, plastination techniques have featured studies of more delicate anatomical organization than ever before, e.g., the female urethra,<sup>24</sup> esophageal muscles,<sup>25</sup> bone's morphology,<sup>26</sup> skin ligaments,<sup>27</sup> and spinal cord.<sup>28</sup> In recent times, plastination products are not only appreciated as teaching or training tools but also as research tools throughout medical, biomedical, veterinary and health science institutions.<sup>2</sup> However, it seems that many of our anatomists have not yet realized the potential revolutionary significance of using plastinated specimens in research on anatomy teaching methods. For example, Lozanoff et al.<sup>29</sup> illustrated a

method for developing animations using plastinated brain sections and demonstrated how realistic anatomical animations can be generated quickly and inexpensively for use in medical education. Cheng et al.<sup>30</sup> showed that plastinated human hearts were subjected to cone beam computed tomography and a graphics program (ER3D) was applied to generate 3D cardiac models for use in radiologic anatomy teaching. Durand et al.<sup>31</sup> made a plastinated nasal model with a realistic cast of nasal airways which exhibited a high level of anatomic quality, including a very good mucosa preservation created a potential tool for nasal flow, drug delivery and aerosol deposition studies. Moreover, ultrathin plastinated slices are obtained and used to construct precise 3D computer models of anatomical structures.<sup>32</sup> Several studies reported that the use of plastinated specimens as teaching resources does improve the quality of teaching and learning in anatomy.<sup>4,5,20,21,23</sup> This type of teaching material may improve the teaching and learning process not only in anatomy, but also in other disciplines (e.g., pathology, surgery, obstetrics & gynaecology, radiology).<sup>3,33-36</sup>

### Disadvantages

Setting a plastination laboratory to produce plastinated specimens is very expensive especially for low-income countries like Bangladesh.<sup>37</sup> Some other important drawbacks are: time consuming procedure, high cost of the instruments and chemicals, limited size of the available impregnation chamber as well as health hazards (e.g., respiratory and dermal irritation, vomiting and unconsciousness) and environmental hazards (e.g., water pollution) of the chemicals used in the process.<sup>21,37,38</sup> It also requires skilled manpower.<sup>37</sup> Last but not the least, using plastinated specimens is seen as a compromise to the traditional wet cadaver based teaching and learning, because of its restrictions in terms of tactile and emotional experience that is delivered by wet cadaveric specimens.<sup>21</sup>

## Plastination in Bangladesh

To our knowledge, there is no known report of the use of plastinated specimens in Bangladesh as teaching aids in medical education.<sup>39,40</sup> The first plastination laboratory of the country has been established in the Department of Anatomy under the Faculty of Basic Medical Sciences of Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, in 2012, funded by the Higher Education Quality Enhancement Project (HEQEP) of the University Grants Commission (UGC), Bangladesh, as provided by the Academic Innovation Fund (AIF) of the World Bank.<sup>39</sup> Prof. Khondker Manzare Shamim, Ex-chairman of the department, led the project. However, it is still in the experimental level. Postgraduate research has been going on based on plastination of pig's organs.<sup>40</sup> Plastination of those specimens are currently being done by the "S10 Standard Method", as described by von Hagens.<sup>13,38,40</sup>

## Conclusion

Plastination seems to have a great future in all fields of teaching, training, and research not only in anatomy education but also in other disciplines throughout the world. With advancement of plastination technique plastinates are now produced fast, more in amount, and less hazardous and using a widespread supply chain of plastinated products have become more available than before; therefore, many departments of medical, biomedical and health science institutions are consuming those as teaching and research tools. The plastinates have opened several new windows to the world of anatomical science both for the teachers and the learners. However, in our context, plastinates are not regarded as replacement for traditional cadaveric dissection rather it offers an additional learning opportunity to know and understand complex human anatomy and paves the way to further research in anatomy education. Last but not the least, ethical standards must be upheld while dealing with such human remains. If specimens are no longer needed, they should be cremated and buried.

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