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Role of Plastination in Anatomy Education

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Abstract:
Dissection of a dead body is a time honoured element of medical education as a component of learning human anatomy since the time of Vesalius. However, lately dissection of cadavers for teaching and training purposes is surrounded by many ethical and other uncertainities. Hence many universities have shifted towards alternative modalities of teaching involving cadaveric plastination, non-cadaveric models and computer-based imaging. Plastination is the process whereby the water and fat of the tissues are replaced by certain plastics, yielding specimens that not only retain most properties of the original sample but also do not smell or decay. Specimens appear artistic, and do not undergo significant deterioration over many years of continuous use. Plastination no doubt, is a boon for Anatomy as well as for medical practitioners but is it feasible for undergraduate students studying Anatomy. This paper discusses the advantages of plastination as well as dissection and concludes why cadaver dissection should remain as an essential part and indispensible of undergraduate medical education**. Conclusion:** Plastination is a boon for medical practitioners as specimens appear artistic, and do not undergo significant deterioration over many years of continuous use and are thus easy to construe. But it should be reserved for those students who have completed the dissection of the body at least once and are aware of the 3-dimensional anatomy.
Keywords: Dissection, Dead Body, Medical Education, Anatomy, Cadaveric Plastination, Non-Cadaveric Models, Computer-Based Imaging, Dissection.

Introduction:

For years together now, cadaveric dissection has been considered as central to the study of human anatomy and an indispensible part of medical training. Dissection of a dead body is a time honoured element of medical education as a component of learning human anatomy [**1**]. Dissection began during the Renaissance, where anatomists would produce texts illustrated with images based on their dissections. This era of scientific human anatomy was highlighted by Vesalius, the 'real father of modern anatomy' by showing a physician-teacher performing dissection in the theatre surrounded by the students [**2**]. Slowly but surely towards the end of 20th century, dissection became the mainstay of medical education. Dissection is not only a skill, but also the hall-mark of a surgeon. The preliminary knowledge of this skill, comes from the anatomy dissecting room. However, lately dissection of cadavers for teaching and training purposes is surrounded by ethical uncertainties. Maintaining a dissecting room in accordance with ethical standards is very costly. There are arguments on assessment of learning outcomes, teaching methods and resources [**3**]. Due to the advent of science and technology there are increasing concerns that medical education should cater more to ethics, professionalism, and humanism. [**4,5**]. Such topics are competing for time in the curriculum. Moreover, the use of cadavers for dissection in anatomy learning, has been identified by some scholars as expensive, time consuming and potentially hazardous [**6**]. These problems have been identified as some of the reasons why, a large number of universities in USA and UK have planned to abandon anatomical dissections altogether. They have shifted towards alternative modalities of teaching involving cadaveric plastination, non-cadaveric models and computer-based imaging [**7**]. Plastination is a process designed to preserve the body for educational and instructional purposes. It was

first developed by Gunther von Hagens in 1977. The principle behind plastination is that the water and fat of the tissues are replaced by certain plastics, yielding specimens that not only retain most properties of the original sample but also do not smell or decay [**8**]. The first step of the process involves halting decay by pumping formalin into the body through the arteries. The skin, fatty and connective tissues are removed in order to prepare the individual anatomical structures. In the first exchange process, body water and soluble fats are dissolved from the body by placing it into a solvent bath (e.g., an acetone bath). The second exchange process involves forced Impregnation with reactive polymer, e.g., silicone rubber, to replaces the acetone. This is the central step in Plastination. To achieve this, the specimen is immersed in the polymer solution and placed in a vacuum chamber. The vacuum removes the acetone from the specimen and helps the polymer to penetrate every last cell. After vacuum impregnation, the body is positioned as desired. Every single anatomical structure is properly aligned and fixed with the help of wires, needles, clamps, and foam blocks. In the final step, the specimen is hardened. Depending on the polymer used, this is done with gas, light, or heat. Plastination of an entire body requires about 1,500 working hours and normally takes about one year to complete [**9,10**]. Plastination is used at more than 40 medical and dental schools throughout the world as an adjunct to anatomical dissection. Tissues of the body like muscles, nerves, bones, ligaments, and organs can be conserved in a form useful for teaching. Specimens appear artistic, and are easier to construe than their counterparts. They can be handled without gloves and without risk of exposure to chemicals such as formalin. They will not undergo significant deterioration over many years of continuous use. Hence rare specimens can be made available for study. They can be used to describe an anomaly or pathology to a patient. The plastinated specimens retain their conformation, which allows them to be used to teach surgical procedures. Plastinated specimens require little storage and no maintenance. Hence time saved can be used for expansion of the collection rather than just maintaining it. In forensic, preparation of tissue sample can be used as evidence [**11**]. Preparation of plastinated specimens is not without its limitations, as the process is technique sensitive and time consuming. It needs a lot of equipment and also needs a dedicated pathologist. There is a lot of trial and error involved in the beginning to achieve the desired outcome, which might lead to wastage of rare and unusual specimens [**12**].

Discussion:

It has been observed that some universities like New York University, University of California at San Francisco (UCSF) and at Davis, University of Hawaii, and University of Washington had swapped dissection by other teaching methodologies. But within a short time, dissection was restored. New York University's short prosection course was also rapidly restored with a full dissection course. The reason behind the restoration was that the students' deficiency of the appreciation of anatomical facts became perceptible in subsequent years [**13**]. Also as per students' verdict, dissection was challenging but worthwhile. Further, UCSF found that prosections were not cost-effective. Effective prosections consume a lot of time to prepare, and do not last long with a large class. Some of the reasons which strongly advocate a cadaveric centered dissection course and go against the sole use of plastinated cadavers for the anatomy curriculum are first of all the purpose of dissection. The purpose of dissection is that through it, the students in an active way build up a three-dimensional appreciation of body structure. This comprises of how the structures are put together layer by layer, their depth, their size, their relationships with surrounding structures [**14**] and the display of basic muscle actions. The pulse of the dissection hall is to first inspection to differentiate familiar structures from the unfamiliar; analyse what is seen so as to build up a different identity; and finally carry out further dissection to confirm the identity of the different structures, on the basis of its relative structures [**15**]. This is not possible with a plastinated cadaver. During dissection, when the student

cuts and analyses, he knows what he is going to perceive and if the structure is missing, he has learnt some variation. So both ways he has expanded his knowledge. This is the sort of differential analysis which a surgeon uses in his professional life and its acquisition begins in the dissection hall. Model or plastinated structures, do not promote this type of thinking as the structures are already prepared earlier and only kept for viewing. Dissection allows students to take out organs or reflect muscles, revise them, and put them back in their place. They can compare normal with abnormal and even determine some pathologies. It is a known fact that discussion or constructing of facts is a far better way of acquiring knowledge than just reading alone or observing. Dissection fulfils this principle, by permitting the student not only to dissect, but after dissection, the structures reflected or the organs removed can be reinstated. This reconstruction part gives invaluable information to the student which is again not possible with plastinated cadavers as they are rigid structures [**16,17**]. A plastinated specimen is the end product kept before a student. He has not dissected the fat, fascia or the connective tissue covering the organ or in other words, he has not uncovered it. Incising through the connective tissue and fascia is the fundamental nature of a surgeon because it is through these structures that the nerves, blood vessels and even pathological processes are travelling [**18**]. The skill of cutting through these structures is achieved foremost only in the dissection hall. Plastinates do not give this experience to the student. Dissection acts as a medium to introduce and relate anatomy to other branches of medicine. For e.g.- Radiology and Dissection can work synergistically to generate a level of perception that is difficult to accomplish by either technique alone [**19**]. Dissection permits relating of radiological images (X-rays, CTs, and MRIs) with three-dimensional anatomy of the cadavers. When radiological images and dissection are studied together, students develop an unforgettable representation of the structures. Plastination cannot offer this kind of correlation [**20**]. Every cadaver may possess some variation from the usual. The feeling of astonishment at the detection of a variation during routine dissection is an extremely informative and enriching experience, for the student who discovers it [**21**]. In a plastinated specimen there will be either no variation or the same common ones and the specimen will soon lose its novelty. Thus the feeling of discovery is denied to the student. As we are aware, 75% of body composition is water and fat. In plastination, this very water and fat is substituted by a synthetic polymer. Over and above the tissues are painted with vibrant colours to make learning easy. Thus, the realism of the cadaver is lost and its natural colours get veiled [**22**]. A cadaver is like the first patient for a student. With its rich vocabulary, dissection teaches the basic language of medicine. It fosters group spirit and promotes positive interaction [**23,24**]. On the opening day of dissection, the students' are captivated at the first mention of the opportunity of human dissection. Later, they realize that they have learnt from another's selfless gift – to give with little recognition. They will learn to emulate this type of behaviour when they become professionals [**25**]. Study of a cadaver conveys to the student an appreciation of mortality, first that of the cadaver and ultimately his or her own. This helps them to develop attitudes of ethics, compassion, and humanism which are indispensible in the medical profession [**26**]. They can never be achieved with the study of a plastinated cadaver. No matter how vivid the plastinated cadaver is, it will still remain two dimensional and never give a 3-dimensional view of the interior of the body like actual cadavers [**27**].

Conclusion:

Plastination is a boon for medical practitioners as specimens appear artistic, and do not undergo significant deterioration over many years of continuous use and are thus easy to construe. But it should be reserved for those students who have completed the dissection of the body at least once and are aware of the 3-

dimensional anatomy. All these evaluations prove that cadaveric dissections as compared to plastinated specimens are an indispensable part of medical education.

Competing interests:
The authors declare that they have no competing interests.

Authors' contributions:
SPS drafted the manuscript, performed the literature review & SR assisted with writing the paper.

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