Enhancing the Understanding of Anatomy through the Coloration and Plastination of Anatomical Specimens

A. Marchese[1], L. Marchese[1], A. Wischmeyer[1] and K.Falk[1]
[1] Division of Anatomical Sciences, Office of Medical Education, The University of Michigan Medical School, Ann Arbor, Michigan

Abstract

Gross anatomy is a difficult subject for medical school students to learn on a three-dimensional level. Through the use of plastination, organs can be dissected and positioned to display specific structures, and then can be preserved in silicone casts. These three-dimensional specimens serve as useful study aids for students as they help them to visualize and gain a better understanding of the structures and functions of the human body. In attempts to enhance the educational efficacy of plastinated specimens for medical students, a branch of research has been devoted to the coloration of finished plastinated specimens. When painting the specimens, vessels and nerves are color coordinated to provide better visuals for the students. Using colored specimens, a student cannot only view the anatomy three dimensionally, but they can also better distinguish specific structures of the specimens. In the past, specimens that were plastinated and colored by conventional application of acrylic paints showed a significant deterioration of paint following continued handling over time. This was because the paint did not adhere well to the silicone surface of the specimen. After testing several paints, solvents, and primer coats, we found that by using the acrylic paint applied to the specimen prior to catalyst and with ethyl silicate (Silbond-40®) coated on top of the paint followed by a final coat of lacquer after the catalyst was applied, the new application demonstrated more paint durability that withstood vigorous handling.

Introduction

Plastination is a process that was invented in the mid 1980s by Dr. Gunther von Hagens,[1] and it is a method used for the preservation of tissues, organs, and entire bodies. Students have demonstrated that anatomy is a difficult subject to learn since pictures and plastic models do not convey the proper spatial relationships that a real model or cadaver can display. Implementation of plastinated specimens into medical education is very helpful for students to understand and learn this complex field. It provides them with real specimens of human anatomical dissections that can be handled by the students. To provide more helpful displays of anatomical structures, colors are added to highlight specific features of the specimen. Handling tests were conducted by unbiased medical students to assess which types of paints were most durable. These tests were designed to determine which paints best adhered to the neurovascular pathways, and whether these paints would adhere better before or after the application of catalyst to the specimens.

The validity of colored plastinated specimens in facilitating anatomy education was previously assessed through surveys administered to first and second year medical students. The results showed an overall acceptance of colored plastinated specimens as being a beneficial addition in their learning of human anatomy.[2]

Thus, the goal of our research was to find a coloring method that would better adhere to the specimen in order to make them more useful learning tools.

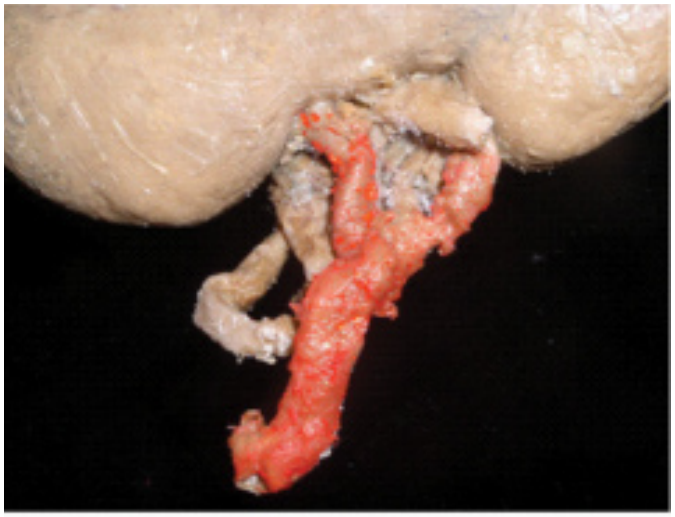
Materials and Methods

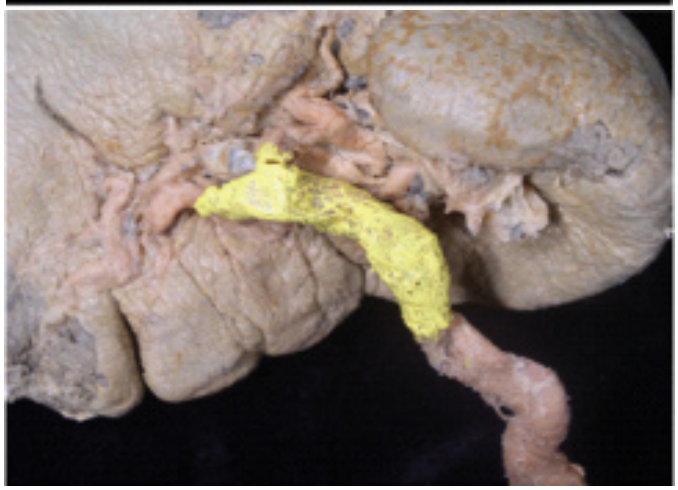
All specimens used in this work were carefully dissected to display neurovascular pathways before undergoing the process of plastination. Specimens were first placed in an acetone bath for several days for dehydration. Specimens were then placed into a low-pressure chamber where acetone was boiled out of the specimen and Silicone PR-10® and Cross- linker CR-20® was forced in to permeate the tissue.[3]

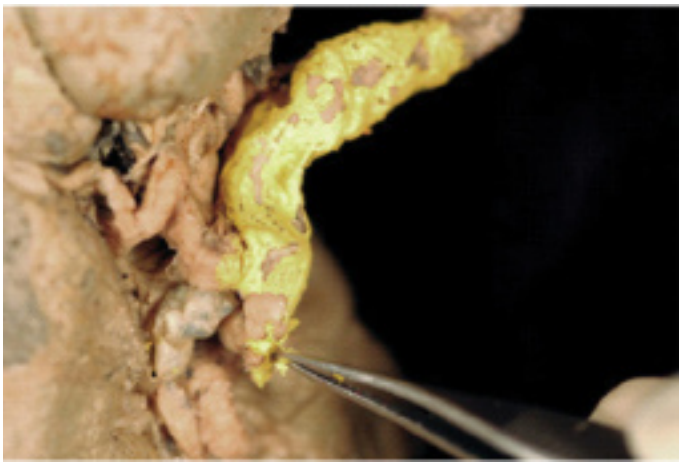
A variety of paints and coloring materials were tested on neurovascular human tissue, including Createx Pure Pigment®, Lukas® powder pigments, American Tradition® plastic enamel, American Tradition® enamel, Jacquard® dyes, and Winsor Newton® acrylics. Each of these materials was treated equally and individually, and was subjected to the same trials described below.

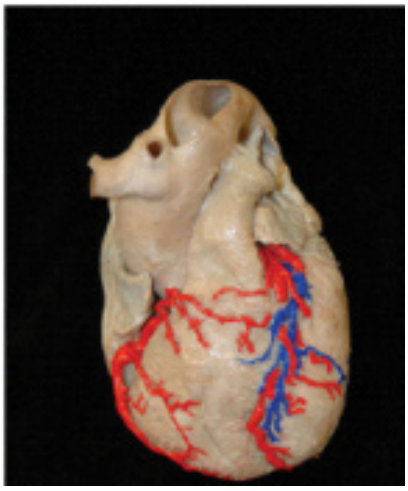
In the first stage of experiments, all paints were tested on a completely finished plastinated specimen in which the silicone had been cured. First, simple application of all paints on the surface of neurovascular tissue was tested to compare the quality and brand of these new materials to the original Tamiya® Acrylic paint. A Windsor Newton® brand gloss lacquer was applied on top of the paints to test if it prevented the acrylics from sustaining damage.

Specialized paints were created to induce silicone compatibility. They were made by individually mixing the coloring materials previously mentioned with silicone based or silicone compatible chemicals. For these silicone bases, we had to find chemicals known for strong









Clockwise from upper left **Figure 1:** After one coat of liquid pigment paint, the renal artery painted unevenly. It requires several coats to maintain an even coloring.

Figure 3: After the catalyst is applied, the enamel paint remains incompatible to the silicone specimen. **Figure 4:** Post catalyst method: lacquer primer on a catalyzed specimen before acrylic paint is applied. **Figure 2:** After one coat of enamel paint, the paint coalesces into patchy areas.

adhesion to silicone surfaces. According to "The Artist's Handbook of Materials and Techniques" by Ralph Mayer, ethyl silicate is used in silicon based paints for outdoor murals and is a substance that can withstand a great deal of weather and chemical abuse. Silbond-40®, a commercially available equivalent of ethyl silicate, was used for these testing methods. Other chemicals used were Silane Z-6040® and the combination Silicone PR-10® with Crosslinker CR-20® which was the same chemical combination used in the plastination process. Each coloring material was tested with these bases in a variety of combinations and applied to neurovascular pathways. Paints and materials were mixed with the bases before application and were made with concentrations near the consistency of a viscous acrylic paint to insure the ease of the paint's application. Paints and chemicals were also applied in layers upon the specimen, first applying the paint followed by a silicone topcoat.

Another alternative was tested to overcome silicone repulsion; application of paint was incorporated into a step during the plastination process, a step which would chemically cure the paints and the specimen itself at the same time. Once a specimen had been infused with silicone, each coloring material was applied onto neurovascular tissue. After the paint had dried, Silbond-40® was applied onto each coloring material. Catalyst CT-32® was then applied to the colored specimen for curing.

Lastly, in order to test the various coloration methods that were attempted, unbiased second-year medical students were given the tasks of testing the paint's durability. While wearing latex gloves, the students rubbed the painted areas of the specimen with their fingers as well as with a probe. These students then recorded how durable the painted areas of the specimens were. This test was done in order to give us an idea of which painting method would best withstand the handling of specimens by students.

Results

From all of the coloring materials listed above, the use of Windsor Newton® acrylic paints resulted in the most durable paint application on neurovascular tissue. All other materials were eliminated when they were observed to be difficult to apply (Fig.1), patchy in the coloring of the nerves and vessels (Fig. 2), and incompatible with silicone (Fig. 3). Most of the problems encountered were a result of water-based coloring materials being incompatible with silicone-based products. Water-based materials were unable to dissolve in silicone-based chemicals, and they also tended to bead on the surface of the silicone infused specimens. Though acrylics contain some water, they are thick enough to maintain cohesion on specimen tissue yet viscous enough to be applied easily.

Of all the methods of applications tried, two procedures produced the most considerable improvements from the original based on the second-year medical student's handling test. These methods are the application of a lacquer primer on a cured specimen prior to painting and the application of acrylic paint prior to the specimen curing (Fig. 4). The first of these can be used at any point in time after a specimen completes the plastination process. This requires that all areas desired to be painted receive a coat of Windsor Newton® gloss lacquer on the surface of the specimen, and, after that has dried, acrylic paint may be applied. The durability of the paint improved significantly with these methods, and the specimen was able to withstand excessive handling without the paint coming off.

Further Direction

In attempting to enhance the education of medical students using plastination, another branch of research has been devoted to dying muscle tissue in order to enhance the appearance of the tissue and thereby create a more life-like model. Dyes are preferred over paints when coloring muscle tissue due to the ability of the tissue to absorb dye. Paint would coat the muscle tissue and detract from the texture of the tissue. The goal is to maintain a lifelike appearance when dyeing muscles, while coloring neurovascular pathways is not intended to be lifelike but rather to makes vessels more distinguishable. Also, when working with such a large surface area, as with muscles, dyes help to preserve the important surface characteristics of the muscle tissue. For example, a dye will not interfere with a student viewing the striations of a skeletal muscle or the transition from muscle to tendon. Paint on the other hand will cover the striations, making it harder to distinguish between and gain an appreciation for the different types of muscle tissue. The dye also makes the task of identifying muscles easier because it allows the student to not only see the muscle shape more clearly, but also locate the origin and insertion.

For these procedures, both liquid and crystallized textile dyes were tested in the same way as the paints on the neurovascular pathways. All materials were subjected to the same trials and combinations of mixtures before being applied by brush to both cured and un-cured specimen. After the dyes were applied they were sealed with Silbond-40® and cured with Catalyst CT-32®.

In the coming months we plan to apply these dye techniques to a full human cadaver and assess how well the dye can withstand handling by the students. We will also conduct surveys to determine if the dye adheres to the specimen and to see if students are better able to understand the anatomy.

Conclusion

The two methods discussed above have shown the improvement of the durability of the paint is considerable. The methods have demonstrated that the specimens are able to withstand student handling without the paint coming off. One method involves applying a base coat of lacquer, which acts as a primer for the acrylic paint on the plastinated surface. The second method combines the painting process with the plastination process. With these new coloration processes, paint can be applied that can withstand handling, allowing the neurovascular structures to be emphasized. Another promising development in the process of producing effective educational models is the use of dye on muscles. Dyes can help distinguish particular muscle groups and also bring a more realistic quality to the specimen. The hope is to provide students with a specimen that will aid them in the rigors of learning human anatomy and physiology, as well as a specimen that accurately models the patients that they will one day be treating.

Acknowledgments

The following people played a crucial role in the process of our work: Dr. Ameed Raoof, Dr. Longping Liu, and Dr. Heping Zhao

References

1. G .Von Hagens. *Heidelberg plastination folder: Col lection of technical leaflets for plastination.* 16 (1985).
2. A. Raoof. *Journal of the International Society for Plastina tion.* **21,** 35 (2006).
3. A . Raoof. *Journal of the International Society for Plastination.* **16**, 5 (2001).
4. R. Mayer. *The Artist's Handbook of Materials and Tech niques.* (Penguin Books Canada Ltd., Toronto,1991), 385.