The Use of Alkyd Resin Method in Wistar Rats for the Preparation of Teaching Materials and Museum Exhibits [1]

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Abstract
Alkyd Resin method, patented by the Turkish Patent Institute, is a cadaver preparation and preservation technique. This study examines whether exhibition-museum materials can be produced from rat cadavers processed with alkyd resin method in different postures and whether dissection and suturing can be performed on the samples. Besides, samples prepared with alkyd resin and samples prepared freshly were compared in terms of dissection and suturing. 14 Wistar Albino Rats were used in the study. Seven were prepared with alkyd resin method and the others were freshly prepared for comparison in terms of suturing and dissection. The alkyd resin method was applied to two cadavers as a pretrial and to five cadavers for them to be museum-exhibition and educational materials. Alopecia was detected in two cadavers. In some of the exhibition samples processed with the method mentioned, shrinkage and hardening of the skin was noticed. All the samples prepared with this method became products suitable for suturing and dissection. The exhibition-museum materials prepared with the alkyd resin method have maintained their first body postures. We believe that alkyd resin method can be applied to the entire body, and the products can be used for exhibition and educational purposes. Furthermore, the method should be further popularized, and it should be applied to cadavers of different species so that its applicability increases.

Keywords: Alkyd Resin, Cadaver, Museum-exhibits, Rat

INTRODUCTION
Anatomy is one of the oldest areas of medicine and one of the cornerstones of medical education. In addition to providing information to students and physicians, anatomy also designs emotions and thoughts regarding the dead body[1,2]. Cadavers have been used for anatomy education and training for centuries. Cadaveric dissection does not only

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provide students with information about the shape and size of organs, but also gives an idea about how each organ is positioned relative to the rest of the body. Dissection is believed to support self-learning and teamwork [13]. However, in recent years, anatomy education has changed drastically due to financial and ethical concerns, developing technology and difficulties in procuring cadavers [4]. The importance of anatomy education in medical schools and concerns about teaching standards should be discussed persistently. After many years, Warner and Rizzolo [15] and Turney [16] brought forward how anatomy education has fallen below the sufficient level. The way to cope with modern practices is to strengthen the traditional dissection education by introducing innovations into it. Many institutions officially reported that traditional cadaver dissection, which replaced introducing innovations into it. Many institutions officially reported that traditional cadaver dissection, which replaced innovat...
prepared for comparison with those prepared with alkyd resin. The combination of 5-8 + 75-90 mg/kg IM Xylazine + Ketamine was used for euthanasia. The abdominal aorta of the animals deeply euthanatized were cut, and their blood was drained out.

2. In the study titled "Examination of the effects of selenium in protecting against the negative effects of amiodarone on the thyroid" conducted in the experimental animals unit, some of the body parts of the animals taken as control group were kept fresh for use in the panel, while others were prepared with alkyd resin in addition to the seven whole body cadavers again for comparison on the panel.

Comparison Panel

Seven whole body cadavers prepared with alkyd resin, seven fresh whole body cadavers taken out of cold storage and body parts were taken to the room where the panel would be held to perform the dissection and suture processes. The panel was held with a total 35 participants in total consisting of lecturers and instructors (PhD students) in the medical and veterinary faculties (eight surgeons, two of whom were general surgeons, seven anatomists, four pharmacologists, four zootechnicians, two histologists and three biochemists who did not know how to perform suture, three physiologists, two internal diseases specialists and two gynecologists). However, five people who did not know how to perform suture were removed from the evaluation. Suture was applied to cadavers’ muscle tissue in the form of simple suture. The people participating in the panel were taken to the hall where the panel was held one by one and asked to answer the questions given in Table 1. The answers were analyzed with the Mann-Whitney U Test.

Preparation of Fresh Cadavers

In the aforementioned study, the sacrificed body parts of the rats used as the control group were kept in the cold storage at -18°C until the day that the panel was held.

Application of the Alkyd Resin Method

Two of the seven whole body cadavers were processed with the alkyd resin method for trial purposes (the application of the method by determining the waiting period in solutions). According to the trial results, five rats in different postures were prepared with the same method to be used as educational and exhibition-museum material. Fixation, washing, dehydration, embedding, pre-drying, impregnation and final post-drying procedures were applied to each sample prepared with the alkyd resin method.

Fixation

The first step of the alkyd resin method is fixation. A catheter was placed into the abdominal aorta of the materials to be prepared for demonstration. After the probing, the vessels were washed with the physiological saline solution administered. Then, the cadavers were brought to the desired position with the help of various ropes, fishing line, cloth and a small hanging apparatus (Fig. 1). Following the position procedure, the animals were fixed by administering Spence’s cadaver fixing fluid via the same vessel by means of the catheter. For a 64 kg living being, this fixing fluid is obtained by mixing 2 L formaldehyde, 4 L methyl alcohol, 600 mL glycerin, 800 g phenol and 3 L water [25]. The materials, which were applied the fixing fluid were placed in 10% formalin, and the fixing process continued for one month. Before proceeding from this step to the next, the cadavers were properly dissected.

Washing

Samples taken from the fixation were washed with tap water for 24 h, and the excess formaldehyde was rinsed out.

Dehydration

The washed samples were processed through 50%, 60%, 70%, 80%, 90% and 96% alcohol series. The samples were kept for approximately eight hours in each alcohol series. The samples taken out of the alcohol were then kept in alcohol-acetone (50% alcohol and 50% acetone) solution for 24 h. In the last part of the dehydration step, the materials were immersed in acetone at room temperature

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Table 1. Panel questions asked for materials prepared fresh and with alkyd resin

<table>
<thead>
<tr>
<th>Applicability characteristics: Dissection and incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>√ Dissection and incision are not applicable (0-2)</td>
</tr>
<tr>
<td>√ Dissection and incision are very difficult (3-5)</td>
</tr>
<tr>
<td>√ Dissection and incision provide limited opportunity (6-8)</td>
</tr>
<tr>
<td>√ Dissection and incision are applicable (9-10)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do you know how to perform suture?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes √ No   ✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If your answer is yes, please mark one of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td>√ Cannot be sutured (0-2)</td>
</tr>
<tr>
<td>√ Very difficult to suture (3-5)</td>
</tr>
<tr>
<td>√ Can be sutured (6-8)</td>
</tr>
<tr>
<td>√ Can be sutured very easily (9-10)</td>
</tr>
</tbody>
</table>

Fig 1. Rat cadaver, which was administered the fixation procedure.
for 48 h. In this way, the fat and water levels in the samples were minimized.

**Embedding**

Dehydrated samples were placed in glycerol in vacuum desiccators and left under vacuum (220-380 mm Hg) for three days. Thus, the tissues hardened by acetone were partially softened.

**Pre-drying**

The samples taken out of glycerol were kept on a blotting paper for three days and cleared of excess glycerol.

**Impregnation**

Pre-dried materials were then immersed in alkyd resin solution in containers with a vacuum feature. They were kept in the vacuum (220-380 mm Hg) for 48 h. Thus, the alkyd resin was ensured to penetrate into the materials, and the impregnation phase ended.

**Post-drying**

The materials that thoroughly absorbed the alkyd resin solution were left to dry under normal room conditions for 15 days, and the alkyd resin method was finalized [18,19,21]. All the products were then taken onto the exhibition stand to protect them from damage after use.

**RESULTS**

The most challenging thing in the presented study was keeping the cadavers in the appropriate position while performing fixation. Alopecia, and shrinkage and hardening of the skin were detected in two rat cadavers used in the trial study (Fig. 2). It is believed that the shrinkage and hardening of the skin, and alopecia are related to the waiting periods during the preparation of the materials. The preparation of the other five cadavers took 26 days, excluding the fixation period. The educational and exhibition-museum materials prepared with the alkyd resin method were found to have preserved their positions since the day they were processed. The original structure and size of the cadavers abdominal and chest organs were also observed to have been preserved (Fig. 3, 4). The panel results for dissection and suturing applications are presented in Table 2. According to the results in Table 2, the difference between fresh and alkyd resin cadavers was revealed to be statistically insignificant in terms of dissection and suturing applications (Fig. 5). The obtained samples have been preserved under room conditions for 46 months.

In terms of dissection characteristics, it was determined that the group with the alkyd resin behaved like fresh tissue and both groups were easily dissectable according to the participants’ responses. Although there was no statistical difference between the responses given to the question regarding the applicability of dissection and incision for both groups, both groups were found to be 100% applicable regarding dissection and incision.

In the study, the participants of the panel stated that cadavers prepared with the alkyd resin behaved like fresh cadavers, and suturing was applicable for both groups.

**DISCUSSION**

Similar to other studies [18,19,21] conducted using the same alkyd resin method, in the present study, an apparent yellow color was not noticed among the observed colors of the samples obtained with the Alkyd resin method. According to the anatomical study conducted by Thomas et al. [26], the presentation style of the anatomical study materials and the lack of the interrelationship between tissues and organs (the presentation of organs separately outside the cadaver) can be a disadvantage for training with cadaver. Whole body cadavers were prepared for the first time with this method, and it was concluded

![Fig 2. Alopecia and shrinkage of the skin](Image)

### Table 2. Panel comparison results of materials prepared fresh and with alkyd resin

<table>
<thead>
<tr>
<th>Processing Properties of Materials</th>
<th>N</th>
<th>Group</th>
<th>Median</th>
<th>M</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>Fresh</td>
<td>10.00</td>
<td>9.30</td>
<td>1.70</td>
<td>4.00</td>
<td>10.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A. Resin</td>
<td>10.00</td>
<td>9.80</td>
<td>0.76</td>
<td>7.00</td>
<td>10.00</td>
<td>.21</td>
</tr>
<tr>
<td>Dissection Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can Be Sutured (Yes)</td>
<td>30</td>
<td>Fresh</td>
<td>7.00</td>
<td>7.73</td>
<td>2.34</td>
<td>2.00</td>
<td>10.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A. Resin</td>
<td>7.00</td>
<td>8.11</td>
<td>1.49</td>
<td>7.00</td>
<td>10.00</td>
<td>.79</td>
</tr>
</tbody>
</table>
that there was no change in the shape and size of the internal organs and the total structure of the cadaver. The cadavers prepared with alkyd resin method in this study, will eliminate the disadvantage of the lack of presentation stated in Thomas et al. [26] in terms of shape and image.

In their study, using an acetone meter, Ekim et al. [27] maintained the dehydration phase of the plastination method until the acetone concentration was balanced. In our study, it was revealed that there is more than one phase in the dehydration phase and an acetone meter cannot be used because of the alcohol use in these phases, and that keeping the samples in the dehydration phase longer causes shrinkage and hardening of the skin. However, it was also determined that establishing a standard in the application of this method for processing the skin of all other living groups was necessary.

Panel participants who knew how to perform sutures evaluated the samples prepared fresh and with the alkyd resin as “suturable”. Only one panel participant (3.3%) emphasized that fresh tissues cannot be sutured. 100% of the participants stated that tissues with alkyd resin can be sutured. Panel participants expressed that dissection can be performed in both groups. This result coincides with the study results of Arı and Çınaroğlu [18], and Çınaroğlu and Arı [19] who stated that procedures such as dissection and suturing can be performed on tissues with alkyd resin.
Lewis et al. [31] argued that anatomical knowledge is required to learn surgery, that basic anatomical information and dissection times offered in the first year are decreasing, and that intern students do not remember this basic anatomical information. The authors state that detailed anatomical knowledge yields a high level of tissue and organ manipulation by improving the efficiency and safety of a surgeon in order to heal and save a patient, which is called anatomical engineering. They argue that while anatomical engineering can also be learned from textbooks, atlases, computer models and projections, dissection is the most efficient method. In the same study, it was emphasized that the fact that endoscopic interventions, which largely replaced open surgeries, are performed on a two-dimensional screen limits the examination of the anatomical structures of the three-dimensional organs. Based on these arguments, they concluded that dissectible cadavers prepared fresh or prepared with alternative methods will increase knowledge and skill in surgical education and specific surgeries. There are also some other studies [26,29] where it is suggested that plastine rodents can be an excellent resource to learn their anatomy and to gain knowledge, and can be useful for innovative applications such as developing practice, comprehension, understanding complex anatomical relationships, surgical maneuvers, endoscopic trials, and developing autopsy protocols [13]. In addition to all these mentioned elements, it is reported that learning a new procedure with daily practices on living beings is quite dangerous for education and that practices on cadavers increase the education experience [30].

The present study proved that the alkyd resin method can be applied to the whole body and supported the arguments of Huri et al. [12], Stuart and Henry [28], Latorre et al. [29], Tjasma et al. [30] and Lewis et al. [31]. They argued that education with cadavers should not only be offered during schooling but should also be used in surgical training, the teaching of various surgical interventions, trial of new procedures and training of specialist physicians.

According to a study, it is estimated that 192.1 million experimental animals (including those that were produced for scientific studies but were not used or could not be used) were used worldwide in 2015 [32]. According to another study, it is stated that approximately one third of the experimental animals are lost as a result of education and wrong practices [33]. People working on laboratory animals should complete their education by avoiding toxic effects of the samples reflecting real tissue and by using the least number of animals [34]. Working with harmless materials reflecting the real tissue also reduces the anxiety that trainees and scientific researchers may have while marking the surgical intervention points, giving training before the study, teaching about anatomic structures, and preventing concerns that may occur with live animals.

With the innovations it will bring to anatomy education, the alkyd resin method may be an alternative to the old dissection methods mentioned by McLachlan et al. [3], Guttmann et al. [17] and McLachlan [8]. On this subject, the studies conducted by Ari and Çınaroğlu [18], Çınaroğlu and Ari [19], Çınaroğlu et al. [20], Keleş and Çınaroğlu [21], and Çınaroğlu and Keleş [22] contribute to gross anatomy. Similar to the abovementioned studies, this study also developed inexpensive anatomical models that can be preserved in room conditions for a long time. In addition to the mentioned studies, this study proved that these anatomical models can be dissected and incised and are suitable for suturing. Furthermore, with the six exhibitions opened in various regions in Turkey so far, this method is estimated to be a method that can be used together with the plastination method. These rat cadavers, which have been produced so far, have been presented to the scientific world for the purpose of exhibition and education, and academicians who want to conduct scientific studies and receive training visit the hall where cadavers are exhibited. In addition to the advantages brought by plastination of rodents stated in Ottone et al. [13], Stuart and Henry [28] and Latorre et al. [29], the alkyd resin method can offer similar advantages in anatomy classes and postgraduate studies.

In conclusion, given the purposes of the study, the alkyd resin method can be applied to the entire body, including skin and internal organs, and the products obtained can be used for exhibition and educational purposes. The technique in question should be applied to cadavers of different species to pursue its dissemination and to increase its applicability. Furthermore, it is believed that the examination of the alkyd resin method’s dyeability characteristics like the ones in the plastination method, which we consider as a reference method in preparation of museum and exhibition materials is necessary.

REFERENCES