Cadaver dissection for oculoplastic procedures: A beginner’s guide

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The purpose of this article is to form a basic guide for beginning the cadaver dissection training programs focused on oculoplastic surgical procedures. Ours was a collaborative study between the departments of Ophthalmology and Anatomy in a tertiary care teaching institute. We formed a step-wise approach to begin the cadaver dissection focused on the oculoplastic surgical procedures. The basics of cadaver procurement, processing, and preparation for dissections were described. The operative requirements of trainees, surgical handling of cadavers, and basic oculoplastic surgical steps were discussed. The types of embalming (cadaver preservation process) and steps have been described in detail. We have emphasized the preoperative discussion about the proposed dissections using standard teachings and skull models for easier understanding. Additional helping tools like soft embalming and injectable substances for better intra-dissection understanding (intra-arterial, intravenous and orbital injections) have been described. Post-dissection cadaver handing and soft-tissue disposal protocols have also been described. Overall, the cadaver dissections provide holistic surgical learning for the residents, specialty trainees, and practitioners. This article may act as a basic step-wise guide for starting the cadaver-based oculoplastic lab dissection in various institutes and workshops.

Key words: Anatomy, cadaver, cadaver dissection, cadaver lab, oculoplasty cadaver dissection

Sound knowledge of anatomy, surgical landmarks, and tissue identification is necessary for safe and efficient surgical procedures.1 In the present era of technology, the popularity of microscopic and minimally-invasive endoscopic surgeries have increased the patient’s awareness of surgical procedures and their expectations regarding outcomes. With the advent of 3D surgical models and atlases, training models, animal models, radiology-based comparative illustrations, and virtual reality-based simulators, the operating room is not the first learning station for many surgical trainees.2–5 These technologies can be easily used in the office, home, laboratory, or clinical setting in any part of the world to educate patients and medical students.

However, many authors have believed, supported, and promoted the importance of human cadaver dissections in providing critical information, long-lasting learning, clarity, and the acquisition of advanced surgical skills. This point has been time and again raised and emphasized by teachers and researchers.1,6–7 Historically, cadaver dissection has been a successful, traditional way of learning applied and surgical anatomy.1 Over time, surgical trainees tend to retain less information about anatomical landmarks during their different specialty training programs. Hence, periodic visits to the local cadaver dissection laboratories provide more clarity about the area in focus and serve as a refresher course for those already in practice.

Why is Cadaver-Based Learning Important in Oculoplastics?

In ophthalmology, the majority of intraocular surgeries are performed via the cornea, limbus, or sclera. For the training of ophthalmology residents, the animal (goat or bovine) eyes provide the necessary tissue feel, affordably. Few state-of-the-art institutes have advanced simulators, which offer pre-programed surgical training in a structured format. However, these technologies are mainly limited to intraocular procedures.8,9

The ophthalmic plastic surgery or oculoplastics subspecialty poses a different scenario in which very few centers have hands-on learning before attending the operation theater. In addition, the learning of oculoplastic surgeries is challenging due to relatively fewer trainers, a lesser number of surgeries compared to other subspecialties, a broader spectrum of procedures, and deep/crowded operative fields with limited exposure.

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access and visibility for the assistants or observers. The vascular tissues (bleeding) and narrow spaces (orbit, lacrimal sac fossa) make surgical simulation extremely challenging. Furthermore, with the advent of COVID-19, teaching hospitals have been reported to be performing fewer elective surgeries, which would mean fewer training opportunities for trainees, especially in a subspecialty like oculoplastics, where the bulk of the surgical procedures are elective.\textsuperscript{10-12}

The authors believe that anatomists play a pivotal role in surgical education by conducting wet lab and cadaver dissection training for various surgical specialties in the desired ethical manner. Based on the published literature, a dedicated cadaver dissection facility or a wet lab enhances the overall learning–teaching experience in the field of oculoplastics.\textsuperscript{[13,14]} But, there is a lack of a structured protocol designed to perform cadaver dissections for oculoplasty procedures in the existing dissection halls or labs.

With this background, the authors present structured, protocol-based guidelines, based on their experience, on how to integrate cadaver dissection–based training into the teaching curriculum. The authors hope that their experience can help in providing a holistic overview or a one-stop guide for other ophthalmology departments aiming to start cadaveric dissection-based training for oculoplastic surgeries.

### Methods

Our project is a collaboration between the departments of ophthalmology and anatomy at a tertiary care teaching hospital in the northern part of India. The department of anatomy in our teaching hospital has been functional since the year 1968. We describe a step-by-step operational protocol in establishing the procedural guidelines for the cadaveric dissection focused on ophthalmic plastic surgery. For this study, all oculoplastic cadaver dissections were performed in the dissection hall of the department of anatomy. The subjects available were the embalmed “whole body cadavers” or “disarticulated cadaveric heads”, which have not been previously used for any similar dissection purposes. However, the subjects were used for other anatomical or surgical dissections after the use for ophthalmic or oculoplastics dissections.

#### Steps

\textit{i. Procurement of cadavers:} The anatomy department routinely performs the procurement of cadavers, which has a 24/7 Body Donation Helpline Programme, running successfully for many years. The anatomy department also receives bodies that have been voluntarily donated by the kith and kin of the deceased, usually within 6 to 24 hours of death, after following an institutional protocol. It includes the declaration of death by a physician, a duly filled and signed will or consent form by the relatives in the presence of two witnesses, and a detailed medical history form. Creating awareness in the community about body donation and setting up a body donation helpline are incorporated to increase the number of cadaver donations. The trained grief counselors help in handling these complex emotional scenarios and motivate people for body donations.

\textit{ii. Preparation and preservation of cadavers:} Once a cadaver is procured, it is preserved in a life-like form by a process called embalming. Embalming also prevents the further decomposition and preservation of the internal organs. The main preservative used in embalming fluid is formalin, i.e., 37% formaldehyde. The details of the embalming fluid are in Table 1. Formaldehyde helps in the long-term preservation of embalmed bodies; however, it causes hardening or stiffening of cadavers and emits toxic fumes which can be carcinogenic. To overcome these limitations, a technique known as soft embalming has been employed using a modified version of Thiel’s embalming method [Table 2]. Apart from the benefits of avoiding toxicity hazards, soft embalming provides a life-like form to the body, preserves the elasticity and resilience of the skin, and less stiffening of joints. Once the embalming process is completed, the embalmed cadavers are kept for 24 hours in a cold chamber. Following this, these cadavers are then stored in cement tanks containing water and formalin as storage fluid. By this technique, the cadavers can be preserved for years in servable conditions.

#### iii. Pre-dissection classroom discussion: In order to maximize the impact of hands-on dissection, the procedures that are to be demonstrated in the session are discussed beforehand in a classroom setting. This includes a comprehensive overview of the indications for each surgery, the instruments to be used for the surgical procedure, possible complications, and an edited surgical video of the procedure. This exercise ensures

| Item                        | Components                                                                 |
|-----------------------------|-----------------------------------------------------------------------------|
| Preservatives               | Mixture of formaldehyde, glutaraldehyde and phenol.                         |
| Germicides (disinfectants)  | Glutaraldehyde                                                             |
| Modifying agents            | Buffers: sodium citrate, inorganic salts, humectants: glycerol             |
| Anticoagulants              | Sodium citrate                                                             |
| Dyes (coloring agents)      | Eosin, Ponceau red                                                          |
| Perfuming agents/Deodorants | Oil of cloves                                                               |
| Vehicles (Diluents)         | Water, alcohols                                                            |

#### Table 2: Components of modified Thiel’s method for soft embalming

| Item                        | Quantity |
|-----------------------------|----------|
| Solution A                  |          |
| Boric acid                  | 3 gm     |
| Ethylene glycol             | 30 ml    |
| Ammonium nitrate            | 20 ml    |
| Potassium nitrate           | 5 ml     |
| Hot water                   | 100 ml   |
| Solution B                  |          |
| Ethylene glycol             | 10 ml    |
| 4-chloro-3 methyl phenol    | 1 ml     |
| Injection solution          |          |
| Sol A                       | 14,300 ml|
| Sol B                       | 500 ml   |
| Formaldehyde                | 300 ml   |
| Sodium sulfate              | 700 gm   |
that the trainees are familiar with the relevant anatomy, the procedure itself, as well as possible complications.

iv. Pre-dissection preparation: The local periorbital tissue preparation was done using a solution of glycerin, water, and gelatin, as described in Table 1. A large gauze piece containing cotton soaked with the solution was kept overnight to cover the whole face of the body. This helps in keeping the tone, the feel, and the elasticity of the skin in a life-like condition.

Specific guidelines for oculoplastics

i. Dissection and demonstration for oculoplastics dissections (Figs. 1 and 2): Our cadaver dissections were focused on particular surgical procedures and the approaches to specific target tissues. The surgical procedures were eyelid reconstruction and blepharoplasty correction, lacrimal canalculus and lacrimal sac surgeries, orbital decompression, and orbital wall fracture repairs. These procedures were performed sequentially on the same cadaver due to independent surgical areas.

a. Eyelids: The eyelid skin, orbicularis muscle, tarsal plate, orbital septum, levator palpebrae superioris aponeurosis/muscle, Muller's muscle, capsulopalpebral fascia, and the orbital fat were sequentially dissected, delineated, and demonstrated [Fig. 3a]. The differences between the surgical anatomy of upper and lower eyelids are highlighted. The definition of medial canthal tendon and its insertions were demonstrated in context to the lacrimal sac. Similar dissections were performed for the lateral canthal tendon anatomy in context with canthotomy/cantholysis and lateral tarsal strip procedure.

b. Lacrimal drainage system: The lacrimal anatomy was described in detail by sequentially demonstrating the size, position, dimensions, orientation, and angulations of lacrimal punctum, lacrimal canalculus, the opening of common canalculus, lacrimal sac, and the nasolacrimal duct. The skin incision for the external dacryocystorhinostomy was described along with bone landmarks. The osteotomies were performed with Kerrison’s bone rongeur [Fig. 3d]. The grayish-white nasal mucosa was exposed. Rigid nasal endoscopes can be used to examine the nasal cavity of the cadaver for approaching the lacrimal sac (middle turbinate) and nasolacrimal duct opening (inferior turbinate). Ali et al.,[15] described in 2018 the morphometry of the lacrimal drainage system in relation to the surrounding bony landmarks and defined anatomical and positional relationships between them in 20 mid-sagittalized heads of Caucasian adult cadavers. The dimensions would be useful for beginners during the dacryocystorhinostomy (DCR) or related surgical procedures. Ali et al.,[16] in 2014, also studied the anatomical relationship of the nasolacrimal duct with the landmarks present over the lateral nasal wall via cadaver demonstrations. They found an inconsistent spatial relationship between the two and advised that these landmarks should not be solely relied upon by the operating surgeons during surgery.

c. Orbit: The approach to each of the orbital walls can be demonstrated via an eyelid crease incision, transconjunctival incision, and transcaruncular incision. Orbital floor fractures commonly present to the ophthalmic emergency room, and symptomatic soft tissue and muscle entrapment require surgical interventions. Orbital wall [Fig. 3b and 3c] and optic canal decompression are indicated for common conditions like thyroid-associated orbitopathy and compressive optic neuropathy, respectively. These procedures happen in a funnel-like surgical field accessible to surgeons only. Hence, the surgical procedures mimicking orbital wall and optic canal decompression can be demonstrated to the trainees on cadavers in a bloodless field.

d. Target surgical procedures: Particular surgeries involve limited surgical-field exposure and intraoperative instrument handling by the trainees. Surgeries like 3-wall orbital decompression, endoscopic DCR with limited septoplasty and orbital fracture repairs can be learnt efficiently via cadaver dissection courses. Navigation-guided surgical procedures on cadavers may also help in avoiding the precious general anesthesia time utilized during real-time surgery.

The protocol for cadaveric dissection for oculoplastic procedures described below is centered around the practical aspects of cadaveric dissection performed by specialty-trained oculoplastic surgeons. The first step is to always pay respects to the cadaver in the form of a thanksgiving prayer [Figs. 1a and 2c].

Preparation of local area and surgical team

a. Local area: Proper cleaning of the periorbital region is done with povidone-iodine solution (10%). A single split hole towel drape is used to cover the region, and the drape is secured with the help of towel clamps to prevent possible spillage during the procedure.

b. Magnification and illumination: A magnified view always provides better details and understanding of the dissected tissues especially working in a bloodless field with pale tissues. Muscle fibers, nerves, blood vessels, and other structures are better appreciated as compared to the naked eye dissections. Moreover, it also provides real-life surgical experience. Using surgical loupes with head-mounted illumination, especially for the lacrimal sac and orbital dissections, is encouraged. The operating microscope can provide adequate and adjustable magnification, illumination, and focusing levels. The in-built recording system can help in reviewing the dissection procedures and in record keeping. However, the authors prefer battery-operated, head-mounted surgical loupes with illumination. These allow more flexibility, maneuverability, and a wider field of view to the surgeon tilt with easier hand-eye coordination for the beginners. The depth of focus and magnification could be limiting factors, unlike the operating microscope. A roof-mounted or pedestal light source comes in handy to provide additional illumination.

c. Surgeon: Standard surgical scrubs are to be worn by all members entering the dissection room. The donning of personal protective equipment, i.e., a face mask, bouffant hair cap, and eye shield (can be worn over the spectacles), are done in a traditional manner [Figs. 1a, 2c and 2d]. After washing the hands with regular soap and water or povidone-iodine (7.5%) scrub, a disposable, full-length surgical gown is to be used to guard against potential spillage of fluids (while drilling bones, etc.). The cloth or linen gown is preferred as it prevents excessive sweating. Single or double pairs of disposable surgical gloves are used.
d. Surgeon’s stool and table: A proper operation table would be ideal with height-adjusting and tilt features. The height of the surgeon’s stool should also be adjustable to prevent any undue stress on the neck and wrists.

e. Surgical instruments [Fig. 1b and 1c]: We recommend the use of good quality surgical instruments, especially forceps, scissors, retractors, needle holders, and blades. The instrument tray is prepared as per routine in a standard ophthalmic operation theater. The disposables, like surgical blades and sutures, should also be of good quality. Regular cleaning and care of the instruments provide the best efficient functionality and longevity. The instruments required for basic dissections are listed in Table 1. However, the surgical instruments deemed unfit to be used in regular ophthalmic OT may be used for cadaver dissections.

The basics of ophthalmic cadaver dissections are explained below:

a. Bone anatomy: We used a human skull with removed calvaria to understand the orbits’ relevant bone anatomy [Fig. 2a]. All seven bones forming the orbit were identified. To appreciate the paranasal sinuses and the thickness of bones, a torch was used to illuminate from within and outside the orbits. Based on the transmittance of light, one can appreciate the relative thickness of the bones and appreciate its impact during orbitotomies. Other structures to be highlighted were the lacrimal gland fossa, nasolacrimal canal [Fig. 2b], lacrimal gland fossa, inferior orbital fissure, ethmoid foramina, and optic canal. The site of bony osteotomy during DCR was demonstrated.

b. Surface marking: This primary step is vital as it determines the area of exposure and incision placement for surgeries. Hence, familiarization with this step leads to a successful beginning of the procedure. The surface markings for dacryocystorhinostomy, orbitotomies, and eyelid surgeries can be repeated multiple times by each candidate of the learning batch. The techniques of local anesthesia can be practiced for various surgeries by passing 23-gauge needles mounted on 5-cc syringes with instructor-led demonstrations of regional nerve blocks.

c. Post dissection: After completion of dissection work, the cadavers should be treated with respect, and utmost care must be taken while handling the residual tissue wastes. Cadavers are to be covered respectfully and handed back to the dissection lab staff members to prepare them again for the subsequent dissection teams. All disposable items should be discarded in color-coded bins as per the national biomedical waste guidelines. The surgical instruments are to be collected and cleaned with running soap and water and then packed in surgical trays, which can be autoclaved. These surgical instruments should not be used for routine surgical procedures.

Advances in Cadaveric Dissections

a. Cadaver dissection is bloodless, and the blood vessels may get missed or incised in a few initial dissections. Hence, for simulating vasculature, an injection of colored silicon or epoxy resins for veins (blue) and arteries (red) can be injected during the preparation of a cadaver. This provides a more realistic anatomical view for the dissector and audience.

b. For simulating orbital tumors, substances like the Strathane polyfoam injection resin (ST524) may be injected inside orbits. It is a mixture of flexible polyurethane resin and high-value polyether polyols. It has a distinct computed tomography (CT) and magnetic resonance imaging (MRI) characteristic that simulates the preoperative planning before the actual procedure.

c. The use of navigation-guided systems, robotic surgery, intraoperative imaging, various endoscopic-guided procedures like optic nerve decompression, and orbital fracture repair requires more instrumentation and infrastructure in the cadaver dissection laboratories.

d. Additionally, advancements in 3D printing technology can provide additional models for learning the surface anatomy and familiarizing the surgeon with intraoperative landmarks.

e. The scanning electron microscopy may provide deeper insights into the complex anatomical and functional structures like the lacrimal pump. Ali et al.,[17] in 2020, shared newer insights about Horner–Duverney’s muscle and its role in the lacrimal pump for tear transport via donor cadaver dissections.
Summary

Why cadaver-based surgical learning? Cadaver dissections provide a genuine tissue-feel, real anatomical landmarks, and simulating operating conditions (aptly draped cadaver and gowned surgeon). The ophthalmology residents are often exposed to surgical simulators before operating the patients for intraocular surgeries. The akin role is played by the cadaver dissections for training the oculoplastic fellows and novice surgeons for basic and advanced oculoplastic surgeries.

Due to the limited availability of cadavers and unfeasible reuse of the same tissue, a similar performance pressure is experienced by the surgeon. It provides a unique opportunity to discover a new surgical technique, modify an existing surgery and hone the finer surgical skills. It improves surgical efficiency and the prevention of lethal complications. These benefits formed the basics of cadaver dissection courses held in a majority of meetings and conferences. The post-course feedback by the audience showed improvement in their augmented operative autonomy, confidence level, and surgical skills. We recommend the use of soft embalming for cadavers to provide a satisfactory hands-on surgical dissection experience for the oculoplastic surgeons and a better view of assistants or students. Hence, we aim to propose a user-friendly beginning guide to cadaveric dissection teaching and training for ophthalmic plastic surgery. At the end, we would like to highlight the more prominent role of a grief counselor and body donation helpline attendant in creating more awareness about the possibility of organ donation along with the donation of the body for better service to humanity.
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