A Three-Dimensional Model for Teaching Patients about Eye Loss and Prosthesis Wear

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ABSTRACT: *Patients who lose an eye often need information, direction, and words of encouragement. Frequently, ocularists are called upon to provide this support and education. Presented here is a teaching model useful for conveying the broad concepts of surgical eye removal and prosthetic reconstruction. The article provides historical context for the construction of detailed anatomical models, including eye models, and their use in teaching. The construction of this present-day teaching model from materials readily available in the ocularist's office is described step by step. Ocularists and other eyecare providers can replicate this model or contact the author for more information.*

KEY WORDS:
Anatomic model, artificial eye, ocular implant, ocular prosthesis, patient education

INTRODUCTION

The study of eye anatomy is a cornerstone of ophthalmic education. It is also an important asset to the ocularist, as anatomical knowledge is important for teaching patients about eye disease and care.[1-3] This knowledge also helps ocularists create more natural-looking prostheses and can aid communication among ocularists, surgeons, and patients for the patients' ultimate benefit. Various teaching models of the human eye are commercially available for eyecare providers. These models show the eye's internal and ancillary structures and the extrinsic eye muscles. However, virtually no useful commercial models exist for instructing patients about eye loss or how prosthetic eyes are made and used. Some ocularists use modified commercial models, including promotional models from pharmaceutical companies, to address their patients' questions. These models are not ideal because they do not illustrate enucleation or evisceration or demonstrate for patients how an ocular implant and prosthesis work together. They also do not allow a patient to practice handling and caring for a prosthesis. This article describes the development of a model that addresses all the issues above, is aesthetically pleasing, reflects the high quality of the ocularist's work, and is easy to display, store, and transport (Figure 1). Other healthcare providers, including ophthalmologists, could use this model as a teaching tool. The model is placed in the historical context of anatomical teaching models in general and eye models in particular. While most of these models were used to teach medical students, some antique models were also exhibited for entertainment or public health value.

FIGURE 1 The featured 3-dimensional ocular implant and prosthetic eye model described in this article was a salon submission at the American Medical Illustrators Association annual meeting, held July 2011 in Baltimore, Maryland.

A BRIEF HISTORY OF ANATOMICAL MODELS

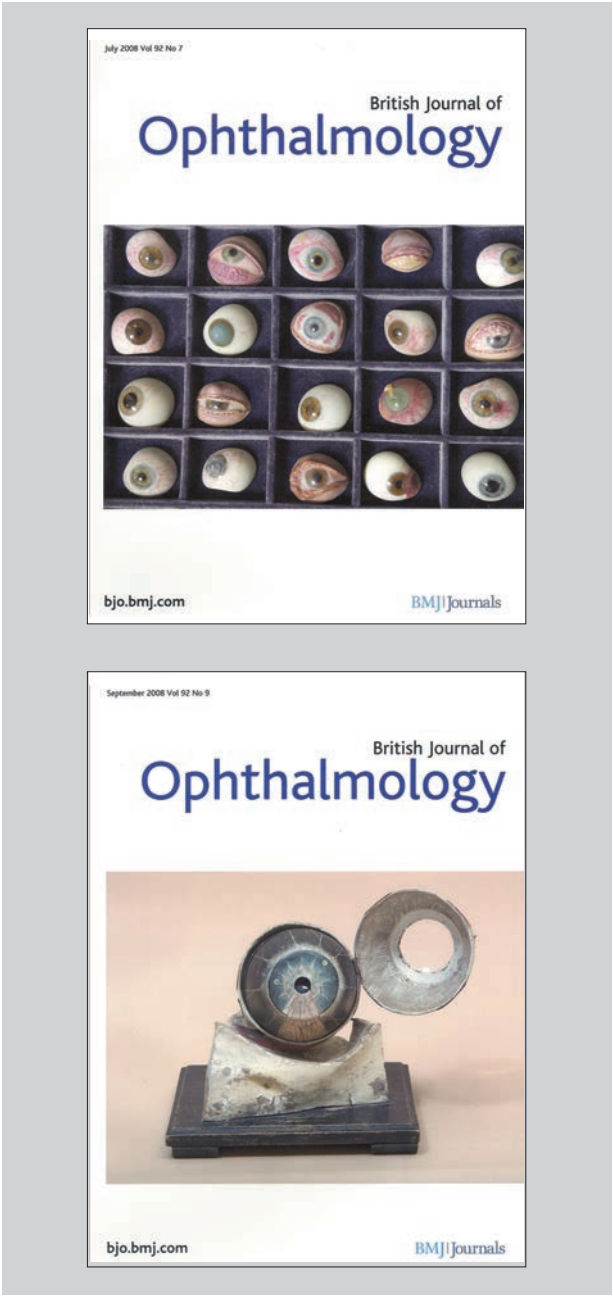
In medical education, models of human gross anatomy were first made after about 1500.[4, 5] They were made of wood, *papier-mâché*, plaster, and wax, as well as precious materials such as ivory.[4] Such models were essential for studying structures difficult to appreciate in gross dissection because of their minuteness, especially to the unaided human eye. With cadavers difficult to acquire and preserve, models became important to students and practitioners of anatomy. The model makers aimed to reproduce the human body in a form as complete and true to nature as possible. In some ways, these models were better educational tools than real bodies because specific anatomical structures and systems could be highlighted (and of course, unlike cadavers, they did not decompose).[6] Wax anatomical models are probably the most striking examples of artificial anatomy.[7]

The art of wax modeling reached its height in popularity in Bologna and Florence in the late 1700s with the work of anatomical artists, such as Clemente Susini (1754-1814) and Anna Morandi Manzolina (1716-1774).[8] Creating models was highly labor-intensive, and many cadavers were needed. Artists made plaster casts of dissected anatomical specimens, and the casts were then used to produce wax copies. Structures such as membranes were either painted or reproduced with thread. The complete model was normally assembled by a team: a modeler who sculpted the figure and an anatomist or surgeon. Usually, 4 to 5 separate models were necessary to display the body's more complex regions, such as the head or eye. Models were varnished to protect them from dust and create the illusion of living tissue.[9] Many of them, especially models of women, also had allegorical or symbolic meaning. Some of these models were so beautiful that they were not just used for education but also sought by private collectors and museums. In the 1800s, *moulages*—wax models showing injuries or pathological changes in the body—were often exhibited in traveling shows across Europe. Part entertainment, part public health education, they often featured the effects of sexually transmitted diseases, acting as a warning about their dangers.

Model Eyes

While the term "artificial eye" generally refers to human prosthetic eyes, it can also be applied to eye models used in medical training. Models were designed to teach students the anatomy and physiology of the eye, how to recognize diseases,[10] and how to use an ophthalmoscope, an instrument used to view the interior of the eye. Model eyes used for ophthalmoscopy training became popular after the 1850s. By simulating a range of abnormalities, these models helped students recognize glaucoma and other diseases. Students also learned and practiced eye surgery on fresh pigs' eyes mounted in the eye sockets of models of the human face. Models provided an alternative to dissections of the human body, and were especially useful when cultural or legal restrictions made cadavers difficult to source. Again, health risks and problems with decomposition were also avoided.[7, 9-11]

Early anatomical eye models were made from ivory, glass, wood, and wax. In the 19th century, French physician Louis Thomas Jerome Auzoux (1797-1880) popularized the use of *papier-mâché* models (Figure 2, bottom).[7] Made from a mixture of chopped paper and glue, cheap and durable with removable parts, Auzoux's dissectible models were perfect for handling. They were used by universities, hospitals, and schools worldwide. According to Dr. Richard Hicks, director of the Mutter Museum in Philadelphia, antique *papier-*



mâché anatomical models were designed for teaching; they were often larger than life size and could be taken apart in sections. These allowed a professor to lecture on anatomy while an assistant displayed sections of the model to illustrate the talk. See Model Diagrams.

However, even the highest-quality 18th- and 19th-century anatomical models had inadequacies. As French chemist Jean-Nicolas Gannal wrote in 1838, "In brief, these three means to convey science [plates, wax models, and artificial anatomy] have their level of usefulness, but they could never bear comparison with the specific matter of organs; they could be useful to enrich a museum, but never form it."[8]

More recently, the uses of medical models have expanded to include patient education (Figures 3 and 4). For ocularistry, education is essential to the complete rehabilitation of someone who has lost an eye. Understanding how an artificial eye is made and how it works is empowering, giving patients a sense of confidence about wearing and handling a prosthetic eye. In addition, the more informed patients and families are, the more realistic their expectations for wearing prosthetic eyes.[12] See Galeski Optical Compression Presentation. See Boston V.A. presentation.

THE STEPS INVOLVED IN MAKING AN EYE MODEL

There are many issues to consider when setting out to create an eye model for patient education. First, the model should be educational and easy for patients to handle. Such a model can help patients come to terms with the challenges of eye loss and prosthetic restoration. Many patients do not understand or remember the details of their eye loss, implant, or prosthetic eye because they were very young when they lost the eye, years have passed since the loss, or they have avoided

FIGURE 2 The *British Journal of Ophthalmology* featured medical models in the July 2008 and September 2008 issues. The top image, published in July 2008, features mouth blown glass eye models depicting a range of pathologies. These models were made by artists at Theodore Hamblin, Ltd., in London in the 1920s. According to Mr. Richard Keeler, curator for the Royal College of Ophthalmologists in London, England, where these models now reside, Theodore Hamblin, Ltd., was a dispensing optician company established at the beginning of the 20th century. The firm also designed and manufactured ophthalmic instruments and had an illustration department (e-mail to the author, October 2011).

The bottom image, published in September 2008, shows a papier-mâché eye model made by Louis Auzoux in France in the late 1920s. This model is originally from the collection of the Glasgow Eye Infirmary in Glasgow, Scotland. According to Keeler, the Glasgow Eye Infirmary was the oldest eye hospital in Scotland. When it closed in the late 20th century, the Royal College of Ophthalmologists museum acquired a number of important artefacts, including many antique ophthalmic instruments (e-mail to the author, October 2011).

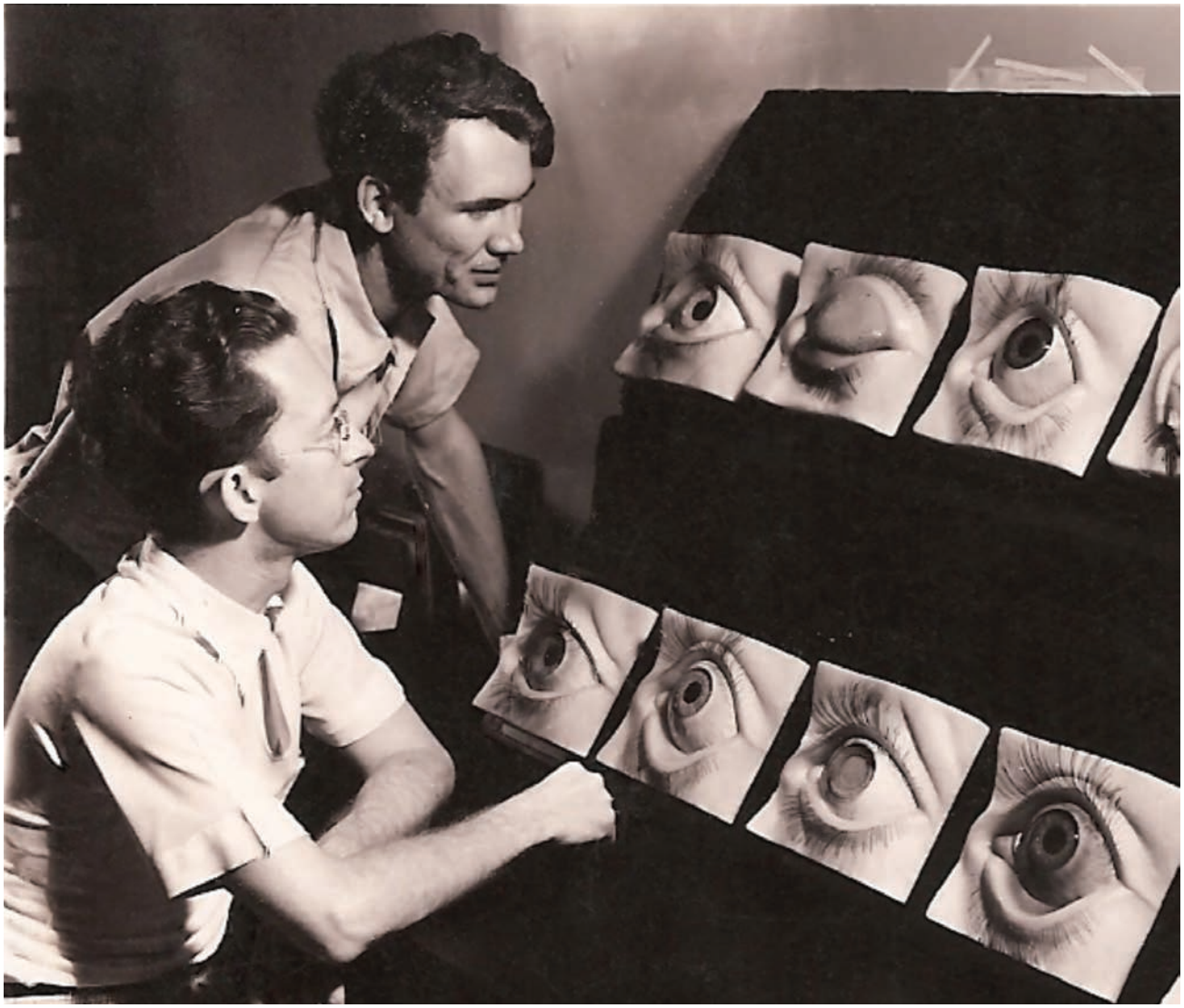


FIGURE 3 This photo, ca. 1939, shows Lee Allen (left) and Emil Bethke with models they made depicting various eye conditions. The models were made with plaster bases, wax skin, acrylic corneas, and horsehair eyelashes, and then painted using oils. They were on permanent display at the University of Iowa after being introduced at the American Academy of Ophthalmology meeting in Chicago, where they received an award. Medical illustrators, including Allen, Bethke, and Leon Schlossberg, often employed their artistic skills and technical knowledge to create displays, including such medical models. Allen and Bethke were founding members of the American Society of Ocularists; Schlossberg, Allen, and Bethke all served as president of the Association of Medical Illustrators. "Schlossberg Industries" was a kind reference to Leon Schlossberg's proficiency in depicting anatomy in print and in 3 dimensions.[19]

learning or thinking about the unpleasant details. In addition, ophthalmologists rarely educate patients about prosthetic eyes. Ocularists play important roles in teaching patients to understand and use prosthetic eyes and accept eye loss.

In addition, the model should be attractive and well constructed. Like other materials associated with the ocularist's office, such as brochures, letterhead, and Web site, educational aids reflect on the ocularist's professional credibility and quality of work. In fact, the quality and beauty of the model's components should give patients a good idea of the artistry the ocularist will employ in making and finishing the artificial eye.

With this in mind, cherry wood was selected for the base of the teaching model for its intrinsic beauty, durability, and attractive finish. The density of this wood also made it a good choice for the precise turning required to finish the spheres representing the eye and the implant. The model of the anatomical eye was created as a 2-piece cherry wood sphere less than ¼-inch thick. It represents the sclera, or outer covering of the globe (Figure 1, far left). The model sclera can be removed to show the vitreous gel inside the globe. As with antique eye models, simplicity was preferred to strict realism for instructional purposes, so the vitre-ous is represented by a solid ball of hand-blown glass 5 inches in diameter (Figure 1, near left). Clear glass was chosen because the vitreous gel of the human eye is clear.[13] The glass ball fits perfectly into the hollow cherry wood sclera model.

The model also includes a second turned-wood sphere that represents the ocular implant (Figure 1, right). This sphere was made intentionally smaller than the first to reflect the implant's smaller size compared to the natural eye. Typically, an ocular implant restores 70% of the human eye's volume, with the prosthetic eye restoring the remaining 30%.[12, 14-15] Since anatomical models and prosthetic eyes are both made of plastic today, poly (methyl methacrylate) (PMMA) was used to make the prosthetic eye represented in this model. A large dental bronze flask was used for investment and heat-curing the plastic. The anatomy of the anterior eye and the wooden eye were suggested using dry pigments, lacquers, and oils.

The thickness of the PMMA used in the prosthetic eye was designed to create the illusion of iris depth, simulating the pupillary opening and allowing enough room to countersink two small magnets at the back of the prosthetic eye. These magnets allow seamless placement, creating the impression that the eye floats on the ocular implant. Texture was stippled onto the surface of the implant to represent the porous texture of an implant made from Medpor biomaterial (Stryker Corporation, Newnan, GA) or Bio Eye material (Integrated Orbital Implants, San Diego, CA). Two dowels, each 2 inches in diameter, were positioned on the cherry wood base to allow easy removal and replacement of the eye and implant/prosthesis parts of the model during demonstrations.

At the rear of the model's horizontal base, two grooves were cut to hold a clear plastic literature rack. This rack holds laminated diagrams that illustrate eye anatomy, removal, and restoration with an implant and prosthesis. Diagrams also depict patients wearing prostheses to illustrate that not every restoration appears perfect; the model is designed for patient education, not sales purposes. Ocularists do not always know precisely what surgical procedure or implant the eye surgeon used, so these diagrams illustrate broad concepts in eye removal. Great attention was paid to depicting the prosthetic eye anatomy (Figure 1, right),[13, 16-17] whereas the diagram accompanying the left model shows only basic elements, including the retina (Figure 1, left).[18] Again, this design was because the main purpose of this model is to show prosthetic restoration. Finally, Plexiglas labels engraved with general information about prosthetic eyes were affixed to the display's base. The model's flat, smooth surface makes it easy to disinfect. Figure 5 shows some of the steps in fabricating the model. See Model Diagrams.

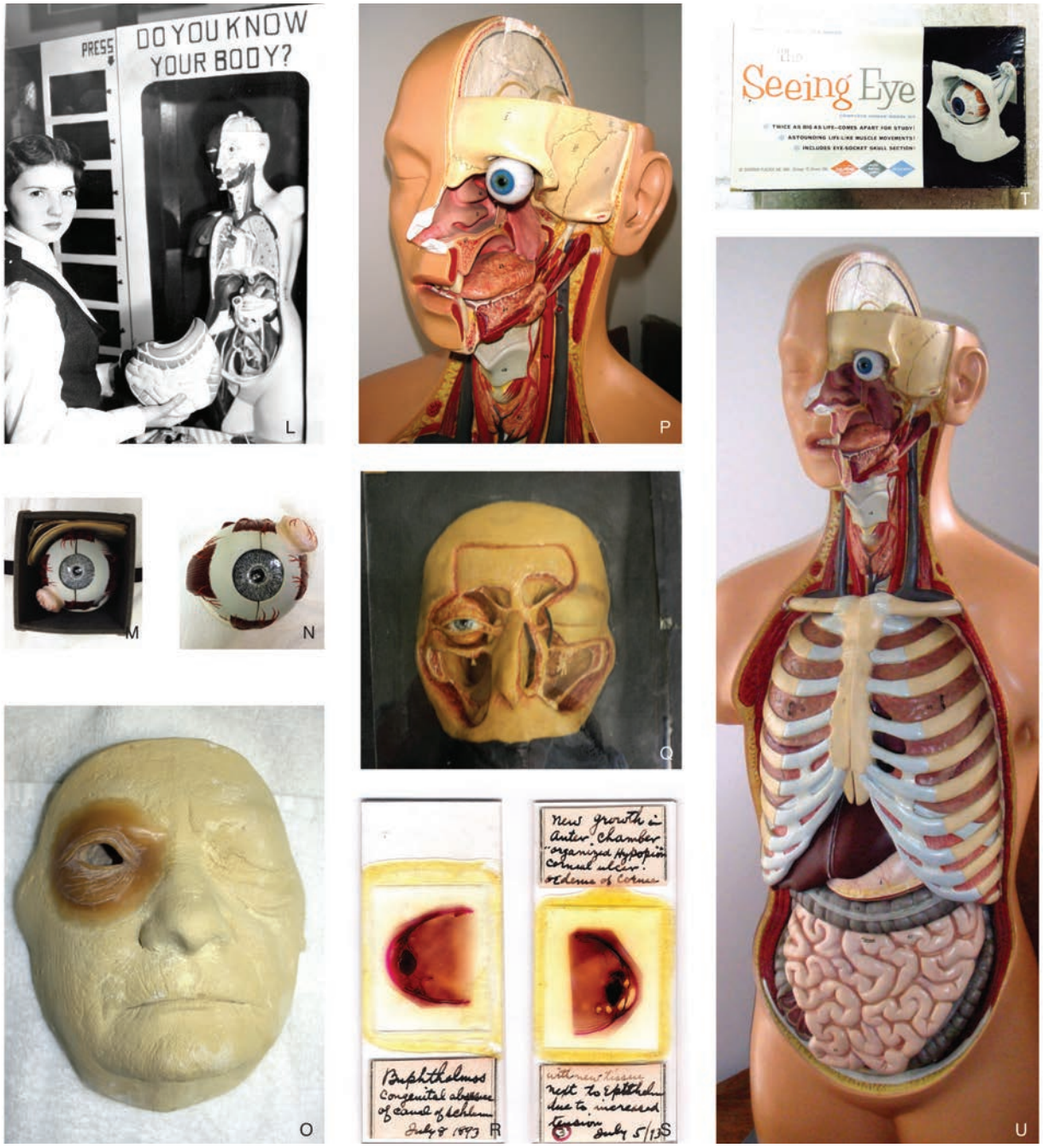
CONCLUSION

Eyecare providers, including ophthalmologists and ocularists, need specialized educational materials to enhance understanding in patients who are candidates for eye removal. These patients' concerns include the medical procedure, eye replacement, and post-surgical appearance. The eye model described in this article il-lustrates the messages ocularists regularly give patients, including:

- You do not have to wear a patch.
- Your eye will be replaced with an ocular implant that moves in a realistic way.
- Your custom ocular prosthesis will resemble your other eye, balancing your facial appearance.
- One month after your surgery, your custom artificial eye will be delivered.
- The prosthetic eye is durable and needs minimal care.

The materials readily available in an ocularist's office and used to make this model emphasize that ocularistry is an art. This model helps reassure patients that their prosthetic eye will be attractive, comfortable, and a close match for the natural fellow eye. The model, which is designed for discussion with patients and family members (see Figure 6), includes elements

FIGURE 4 These images show various educational models of human and prosthetic eyes. While they were used as teaching tools, many of these antiques also stand alone as unique art objects, displaying their makers' craftsmanship. These displays include: A. Photograph of a workman bringing an oversized model of the human eye into position in the main exhibition hall of Funktower, Germany, 1952. B. Manufacturing display showing the various stages of the Galeski Optical Compression molded prosthetic eye. Richmond, Virginia, 1948. C. Promotional plastic model for Timoptic (Timolol Maleateimsd; sterile ophthalmic solution), Merck & Co; 1963. D. Promotional plastic model for Trusopt, (Dorzolamide Hydrochloride ophthalmic solution) Merk and Co; 2005. E. Bulgarian human eye model with various detachable structures, hand made construction in plaster, wood and glass with labled anatomy; ca 1890. F. Hand blown glass sphere complete with contact information (perhaps used as a calling card) by eyemaker J. R. Ballard of Chicago, Illionois, 1948. G-H Various plastic eye models by Koln, German manufacturer, (Deutsches Gesundheits Museum), 1950-1960s. I-J. Scholastic carrying case



(**FIGURE 4 continued**) and eye model (complete with anatomy instructions and cassette for audio information) by Scokie Anatomical company, Chicago, Illinois, 1975. K and O. Facial Moulage – wall display showing exenterated (OD) orbit and wax pattern as part of the prosthetic reconstruction of a patient, 2010. L. Photograph of a sixteen-year-old high school student presenting at an exhibit at the Illinois science fair in Chicago, 1954. P and U. Close up of (plaster) anatomy torso (with detachable organs) which features hand blown (OS) human eye made by the German model maker Haas, 1965. Q. Traditional wax model showing various layers of the human mid-face, including intricate structures surrounding the (OD) eye; encased in black box with glass shield; Columbia Presbyterian Hospital, NYC, ca 1910. Artist/sculpture unknown. R-S. Human eye pathology slides from manufacturer R. and J. Beck, London; individual slides all hand labled and dated 1890's. T. *The Seeing Eye*, finely detailed plastic human model kit for children/educational purposes; Superior Plastics Inc, Chicago, 1961.

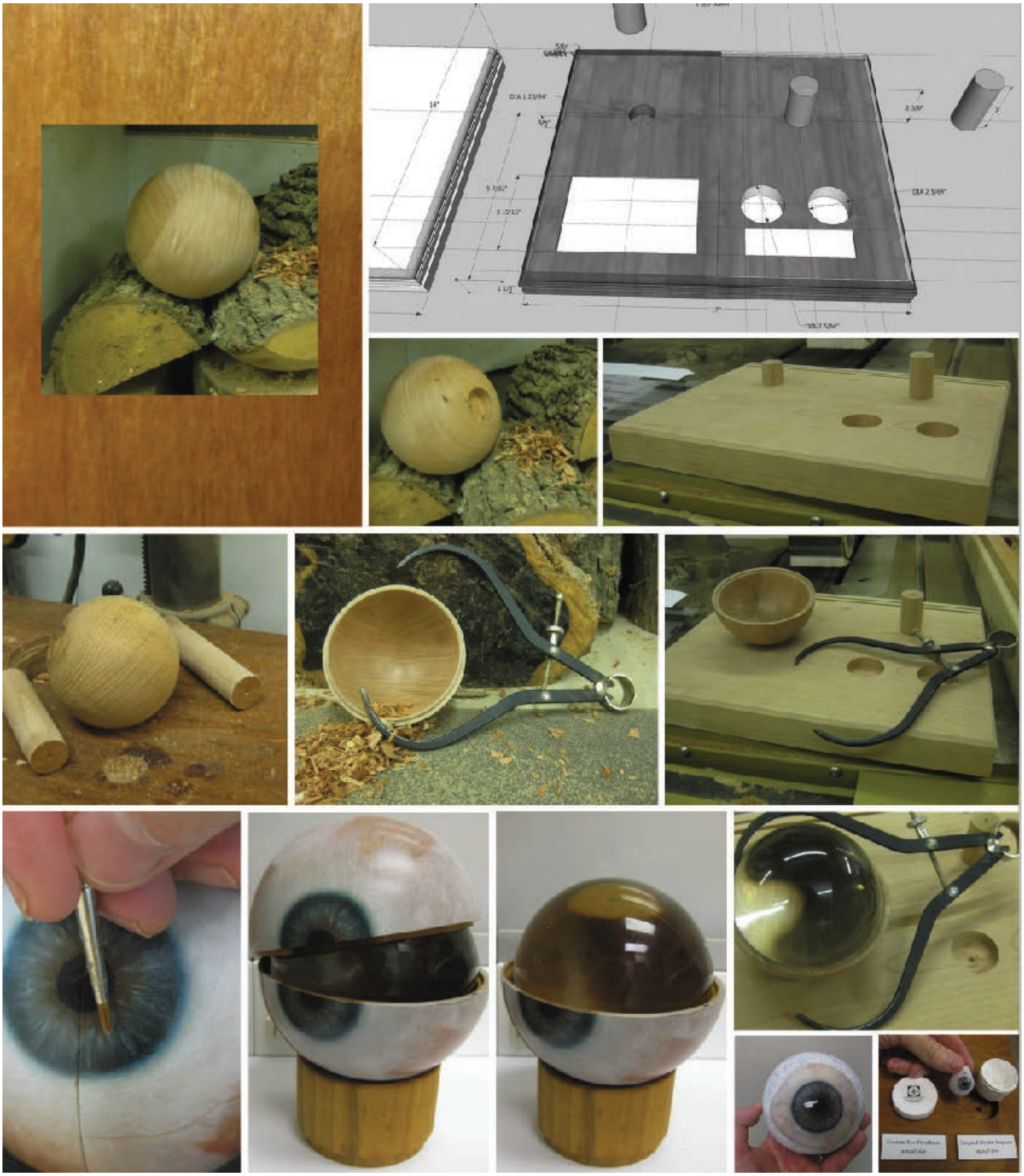


FIGURE 5 These images show the steps involved in fabricating the 3-dimensional ocular implant and prosthetic eye model. The steps below are shown top to bottom, left to right: 1.Cherry wood is used for the base and the two spheres representing the human eye and the ocular implant; 2. Digital plans for the model's base; 3 – 5; Wooden dowels are used to position spheres on the base; 6,7. The hollow wooden spheres are designed to hold glass spheres that represent the vitreous of the human eye; 8. Oil painting is used to create the iris stroma and surrounding anterior eye anatomy; 9,10. The removable acrylic prosthetic eye is secured to the ocular implant with magnets; 11-13. The prosthetic eye and ocular implant, both actual size, are secured to the model's base.

FIGURE 6 This collage shows realistic surgical and prosthetic restorative results in various patients. It is displayed on a laminated panel, with a tab positioned for easy reference. Oversized text and large, bold images and illustrations are used on all eye model panels to aid monocular patients and those with low vision. The collage is a pleasing office display.

that prompt disclosure of concerns and fears about eye loss, help demonstrate prosthetic eyecare (e.g., wiping the eye), and reassure patients (e.g., photos of patients with prosthetic eyes illustrate the natural appearance of a custom prosthesis). Ocularists play a unique role in rehabilitating patients after eye loss. They are often part of highly personal discussions and spend a great deal of time working close to patients in a wounded area of the anatomy. Patient education tools to facilitate discussion, improve learning, and inspire confidence can be valuable in this setting.

The model can be taken apart and put back together easily using its internal magnets, and the display includes written descriptions of each graphic element. An additional feature is that the ocular implant and prosthetic eye samples are actual size, allowing patients and families to handle items similar to what they will use daily. Finally, the model was designed in a size and shape that fit easily on an office desktop or bookshelf, and it can be dismantled for convenient storage. For construction diagrams and specifications for the model, visit the American Society of Ocularists Web site at www.ocularist.org.

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to the *British Journal of Ophthalmology* for permission to reprint the July 2008 and September 2008 cover photographs shown in Figure 2.

The photograph in Figure 3 is used by permission from the University of Iowa Department of Ophthal-mology and Mary Lee Hoganson.

SPECIAL NOTE

The model described in this paper and shown in Figure 1 was presented at the 75th annual meeting of the American Medical Illustrators Association in Baltimore, Maryland, July 2011. It received favorable reviews in the 3-dimensional salon for professionals.

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