Clinical Ocular Prosthetics

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Preface

Prosthetic eyes have a history that stretches back to at least 2,900 BC. Prosthetic eye materials and techniques have evolved in keeping with the times: from clay, to wood and ivory, to enamelled silver and gold, to glass and, finally, to (poly)methyl methacrylate (PMMA) plastic. This last step (from glass to PMMA) was accompanied by a change in the profession that supplied and fitted prosthetic eyes. PMMA eyes could be custom-made, but this required a different skill set to the one that optometrists had used successfully with glass for the previous 500 years. The technological and professional dislocation that the change from glass eyes to PMMA eyes brought about 70 years ago possibly accounts for the almost complete absence of prosthetic eye literature today. The knowledge underpinning the modern practice of ocular prosthetics appears to be based upon clinical observations acquired from practicing ocular prosthetists (ocularists) and the analogous fields of dental technology and contact lenses. This book has come about because of the sincere desire of the authors to provide a more scientific knowledge base for the clinical practice of ocular prosthetics by bringing together information from the literature on ophthalmology, prosthetic eyes and contact lenses and from experts working in these fields.

The genesis of this book started when Keith Pine approached the University of Auckland's School of Optometry and Vision Science to seek advice about how best to go about writing it. He was introduced to Associate Professor Robert Jacobs who supported the concept of the book but felt that the lack of scientific knowledge in the field was a major drawback and that more formal research should be undertaken into prosthetic eyes before a book should be contemplated. That was 6 years ago. The discussion resulted in Keith Pine enrolling in a Master of Science programme (later upgraded to a PhD) and undertaking a systematic set of individual investigations which has resulted in the publication of eight scientific papers to date. Associate Professor Robert Jacobs and Dr Brian Sloan supervised the research and were co-authors of the published papers.

The research began with a survey of anophthalmic patients to confirm a research focus that most reflected their needs. The results of the survey highlighted the concerns that patients had at the time of eye loss as well as their ongoing concerns after at least 2 years of prosthetic eye wear. The health of the remaining eye was their greatest concern at both occasions in time, but second on their list of ongoing concerns was anxiety about mucoid discharge associated with their prosthesis. Frequent, viscous discharge affects the quality of life of prosthetic eye wearers as it can be difficult to live with a continuously suppurating eye that requires constant wiping.

Because of the high level of concern about discharge expressed by patients, mucoid discharge associated with prosthetic eye wear was confirmed as a worthwhile research topic; however, the scale of the problem amongst the anophthalmic population remained unknown. Also unknown were the demographics of anophthalmic patients, the aetiology of eye loss and eye loss trends in New Zealand. A second survey, larger than the first, was undertaken, and 430 prosthetic eye wearers from throughout New Zealand completed a questionnaire about their experiences with ocular prostheses. Included with the questionnaire was an invitation to participate in further prosthetic eye research, and 330 prosthetic eye wearers agreed to do so. The results of this survey confirmed that mucoid discharge associated with prosthetic eye wear was indeed high on patients' list of concerns and that mucoid discharge was widespread in New Zealand even though patients had good access to prosthetic eye services.

A search of the literature and of ocular prosthetists' websites was undertaken to investigate what was known about the causes of discharge and to gain an understanding of the range of treatments for mucoid discharge associated with prosthetic eye wear. This search produced a comprehensive list of known specific causes of mucoid discharge, but there remained a large and under-investigated group of patients with non-specific discharge for which many contradictory and inconsistent causes and treatments had been postulated. A survey of members of the American Society of Ocularists in 2007 carried out by K. L. Osborn and D. Hettler also found that a standardised set of treatment protocols for managing discharge was lacking.

Further analysis of the responses from the New Zealand survey provided evidence of an association between the frequency of prosthetic eye cleaning and severity of discharge. Unfortunately, the direction of cause and effect could not be established – either frequent cleaning was causing the discharge or the discharge itself was the reason patients cleaned more frequently. To resolve this issue, further research into the socket's response to prosthetic eye wear was planned. This research involved an examination of surface deposition on prosthetic eyes (which 47 % of ocular prosthetists' websites claimed was a main cause of mucoid discharge) and examination of the conjunctiva of the anophthalmic socket.

However, surface deposits could not be investigated unless a technique was found to enable them to be seen, and neither deposits nor the conjunctiva could be examined unless measuring tools were developed for this purpose. A staining technique to make surface deposits more visible was found, and for the first time it was possible to investigate changes in the amount and extent of deposition on prosthetic eyes. It was then necessary to develop and test equal interval photographic grading scales to measure these changes. At the same time, equal interval photographic grading scales were also developed to measure the severity of conjunctival inflammation in anophthalmic sockets.

The staining technique and the tools to measure surface deposition on prosthetic eyes and the severity of conjunctival inflammation were used successfully to provide a quantitative assessment of prosthesis cleaning effectiveness and to identify associations between deposits and discharge and deposits and conjunctival inflammation. Again, the direction of cause and effect of these associations could not be established at that stage. Evidence was found, however, that suggested that surface deposits themselves did not inflame the conjunctiva or cause discharge in anophthalmic sockets where the prosthesis was cleaned infrequently.

The next set of experiments was designed to understand more about the characteristics of deposition and to find if a causal link could be established for the association between deposits, inflammation and discharge. The experiments involved both in vitro and in vivo tests of surface wettability and deposition rates on different prosthetic eye surface finishes. It was found from these experiments that rates of deposition were influenced by surface finish and that the presence of deposits caused a significant improvement in surface wettability. It seemed likely that the improved surface wettability would allow prosthetic eyes to be lubricated more effectively by the socket fluids, thereby reducing mechanical irritation of the conjunctiva. The evidence was building to suggest that the presence of at least some deposits was not only not harmful but actually beneficial, causing reduced conjunctival inflammation and discharge in anophthalmic sockets with prosthetic eyes.

This concept was further explored in the next study. It described the build-up of deposits over time and investigated the two distinctly different areas of deposition revealed by the deposit staining process: the inter-palpebral zone where stained deposits are mostly absent and the areas in continuous contact with the conjunctiva where deposits mostly settle. The deposits in the inter-palpebral zone appeared to behave like deposits on contact lenses where they may dry out and irritate the palpebral conjunctiva, whereas the presence of deposits elsewhere on the prosthesis appeared to be beneficial.

The combined results of all the investigations culminated in a hypothesis for a three-phase model of the anophthalmic socket's response to prosthetic eye wear and a protocol for the management of non-specific mucoid discharge – these topics are discussed fully in Chaps. 8 and 9, respectively.

This book, then, derives from the research described above and the successful amalgamation of a research team comprising an ocular prosthetist, an optometrist and an oculo-plastic surgeon. It contains a mix of scientific evidence and clinical experience and includes inferences based on material from other disciplines that are applied to the field of ocular prosthetics but which are in need of corroboration.

The book is written primarily for clinicians and caregivers who have contact with prosthetic eye wearers including ocular, maxillofacial and anaplastology prosthetists, ophthalmologists, ophthalmic nurses, optometrists and students of these disciplines. The book is also a useful resource for other health workers and family members who care for prosthetic eye patients and for those patients who require a deeper understanding of the issues affecting them and their prosthesis than what is currently available elsewhere. The language used in the book may be more technical for some readers than for others, but a glossary of terms is provided and over 400 illustrations add additional explanatory power to the text.

It is anticipated that most readers will consult individual chapters for specific information or for leads to reference material on specific topics of interest. However, many readers will be led down interesting byways because of the breadth of information available and the linking of different topics within the text. For example, the theory of colour is linked to iris painting; socket complications have both prosthetic and surgical solutions; the anatomy of extraocular muscles is linked to orbital implants and prosthetic eye motility.

The book opens with a discussion of the biosocial and psychological aspects of eye loss and goes on to describe the anatomical and physiological features of the face and eyes that are relevant to ocular prosthetics. The causes of anophthalmia and disfigurement of the eye and the implications of congenital anophthalmia and microphthalmia for young children are discussed, and surgical procedures for removing the eye are described.

Subsequent chapters discuss techniques for evaluation of ocular prosthesis patients; techniques for making and fitting ocular prostheses, scleral shell prostheses and prosthetic contact lenses; the response of the socket to prosthetic eyes; and the ongoing care and maintenance of prosthetic eyes. The penultimate chapter provides advice for people who wear prosthetic eyes, and the final chapter summarises the history of prosthetic eyes and identifies the various organisations that form the foundation for the ongoing professional development in ocular prosthetics.

Acknowledgements

As lead author, it falls to me to firstly acknowledge the enormous contribution of my fellow authors. We have worked together now for 6 years and their dedication and commitment to the advancement of knowledge in the prosthetic eye field has been an inspiration to me. The book has had input from many people but in particular, Michael Williams, Maxillofacial prosthetist, Maxillofacial & Dental Unit, Waikato Hospital who contributed valuable input to Chap. 5 in particular, Dr James Partridge, Chief Executive of Changing Faces (UK) who provided expert advice while we were preparing Chaps. 1 and 10, and Neil Handley, Curator of the British Optical Association Museum who contributed both expert knowledge and photographs. Julia Drok created the better diagrams in the book and converted text and photographs to Springer's house style.

The University of Auckland has provided the scholarly environment for the creation of this book but support has also come from the many optometrists and ophthalmologists who work closely with the New Zealand Artificial Eye Service and from the hundreds of anophthalmic patients who have given freely of their time to be either research participants or photographic subjects. Springer is also thanked for sharing the vision to bring this book to press.

Finally, no project of this magnitude can be accomplished without the support of friends, partners and families, and we three authors are very grateful to ours for their forbearance and love over many years.

Keith Pine

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Fig. 1.11 Natahlie is a bright and happy 3-year-old who lives on a farm. One morning a rooster flew at the apple Natahlie was eating but pecked at her right eye instead, resulting in Natahlie losing the eye. Natahlie was excited about getting her prosthetic eye and couldn't wait to check it out in the mirror. In the years ahead, she will depend on her family, teachers and friends to reinforce the positive aspects of being such a unique individual

Fig. 1.12 Greg's right eye was injured during a difficult birth, and while surgeons offered to operate on it at the time, his parents refused because they could not bear for him to go through any more traumas. Indeed, the experience was so painful for them that they ignored his eye's different appearance and never spoke about it. Partly because of this lack of acknowledgment and partly because of the teasing he suffered from other children at school, Greg developed very low self-esteem and a shyness that limited his schooling and his ambitions. Even so, Greg became a quality assurance manager, but it wasn't until a new partner (who happened to have a degree in psychology) persuaded him to seek help that he obtained life-changing scleral shell prosthesis at age 31

Fig. 1.13 Sue (aged 60) lost the sight of her right eye to endophthalmitis following a corneal transplant. For 2 years her eye became more and more unsightly, but she could not face having it removed. 'Eyes are the windows of the soul. It is much harder to lose an eye than to lose other body parts because of the emotional aspects'. Sue eventually plucked up the courage to have her eye removed. 'I should have had my eye out sooner. I wish I had not put myself through such prolonged emotional turmoil'

Fig. 1.14 Mike (aged 50) lost his left eye when he fell on a metal fence post while erecting a fence on a road construction assignment. He remembers that his major concern at the time was not damage to his appearance, but adjusting to using his right eye instead of his left for precision measuring and sighting a theodolite. Mike overcame this problem and continued with his job as a roadwork supervisor where he often jokes about his prosthetic eye with his fellow workers. 'It's a good excuse when I make a mistake'. Mike's open, pragmatic approach is genuine and reflects the fact that for him, the loss of an eye was never a big issue. He is careful to look after his remaining eye however and to ensure that his prosthesis is properly maintained

Fig. 1.15 Tracey was born with a microphthalmic right eye. She was teased at school to the point where she lost all self-confidence and belief. This affected her attitude to life and her education, and she became a miserable teenager with anorexia and bulimia. Things improved for Tracey after her eye was enucleated at age 21, and she had happier times in her 20s. Now in her 40s, Tracey is forward-looking and enthusiastic about her job as a systems manager. She has accepted that there are many more important things in her life than worrying about her eye

Fig. 1.16 Diane (aged 80) has worn a prosthetic eye since her right eye was removed at age 12. Diane's first prostheses were made of glass, and she well remembers selecting her glass eyes from an assortment laid out on trays. She also remembers breaking her glass eye and the drama and stress this caused her poor mother who had to rush her to the optometrist to find a replacement. Diane always left her prosthesis out at night and one morning she couldn't find it. She was very upset because nobody had ever seen her without her prosthesis, and she has vivid recollections of ripping her bedroom apart before discovering the eye mixed up in her blankets. Having only one eye has not prevented her from doing anything she would not have done otherwise – 'it's just felt different'

Fig. 1.17 When Raewyn's right eye was lacerated by a piece of wire at age 40, her life took a dramatic turn for the worse. Her eye became more and more unsightly as her cornea opacified, and she became very self-conscious about her appearance. The stress contributed to the breakdown of her marriage, but after this happened she was forced to take stock of her situation. She had two children to bring up, looked awful and had no career. So what did she do? She began training as a midwife, qualifying a few years later. Raewyn has delivered thousands of babies since then and is now a pregnancy consultant providing expert advice to young mothers. Raewyn's disfigured eye was finally eviscerated in 2007, and she was fitted her new prosthetic eye. 'The difference was amazing. For years I put up with a horrible looking eye and in 6 short weeks I was suddenly normal. I should have had my eye out years ago'. Raewyn is proud of overcoming the loss of her eye and going on to make a difference in her life and in the lives of others

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Fig. 2.31 Triple-layer structure of tear film
Fig. 2.32 A meniscus of tear fluid formed at the margin of the lower eyelid
Fig. 2.33 Same patient wearing a left prosthetic eye at age 40 (*left*) and at age 81 (*right*)
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Fig. 2.35 Following the loss of the globe, the anatomical features of the eyelids do not change
Fig. 2.36 Following the loss of the globe, the eyelids lose support and collapse into the empty socket
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Fig. 2.47 The right prosthetic eye has tilted backwards causing it to gaze upwards and place forward and downward pressure on the lower eyelid
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Fig. 3.24 Tenon's layer has been sutured and the conjunctiva closed. A postsurgical conformer is ready to be placed in the eye socket
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Fig. 3.27 Pegged hydroxyapatite implant
Fig. 3.28 Chronic mucoid discharge associated with a motility peg
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Fig. 4.4 Chart for recording measurements of prosthetic eye symmetry
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Fig. 4.7 An entropic lower eyelid, evidence of mucoid discharge and dried tear protein deposits on the surface of this prosthetic eye are apparent in this photographic record

Fig. 4.8 Photographic record of the extent of medial and lateral movements of a left prosthetic eye. The medial excursion is greater than the lateral excursion, which is common
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Fig. 4.11 Cracks (highlighted by staining) have appeared between the veneer and the base material at the periphery of this prosthetic eye
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Fig. 4.16 Crazed clear veneer due to the use of a solvent to clean the prosthesis
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Fig. 4.24 Microphthalmic left eye
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Fig. 4.29 The PMMA spherical implant in the anophthalmic socket has migrated forward and is covered by very thin conjunctival tissue. It is stable but needs to be monitored
Fig. 4.30 The upper eyelid has been torn away, and surgery is required before a prosthetic eye can be retained
Fig. 4.31 The Castroviejo implant in this socket has migrated forward and can now be seen clearly through the thin conjunctival covering
Fig. 4.32 Exposure of a tantalum mesh orbital implant
Fig. 4.33 White sutures can be seen clearly through the conjunctiva. These may become exposed and require removal

Fig. 4.34 A pyogenic granuloma has formed in this left socket due to wearing a deeply vaulted stock prosthetic eye for many years
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Fig. 4.37 A phenol red thread testing kit
Fig. 4.38 The phenol red thread test for measuring tear volume
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Fig. 4.40 Type III ocular tear ferning pattern (tears from a prosthetic eye)
Fig. 4.41 A Tearscope being used to measure tear film break-up time
Fig. 4.42 Equal interval photographic grading scales for measuring conjunctival inflammation
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Fig. 4.46 Visual analogue scales for measuring the four characteristics of mucoid discharge
Fig. 4.47 The glob of mucoid discharge seen in this socket has collected behind the prosthetic eye
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Fig. 5.1 Used stock PMMA prosthetic eye manufactured in India
Fig. 5.2 Rod and cone cells in the retina of the eye
Fig. 5.3 CMYK subtractive colour diagram
Fig. 5.4 A basic palette might include the colours (from *left* to *right*): ivory black, titanium white, Vandyke brown, cobalt blue, yellow ochre, raw sienna and burnt sienna
Fig. 5.5 A vernier gauge for measuring the iris diameter
Fig. 5.6 Assorted iris discs with matching corneal buttons
Fig. 5.7 Iris disc and clear corneal button with pupil
Fig. 5.8 Metal dies for making iris discs and clear corneal buttons
Fig. 5.9 Sticky wax rod attached to an iris disc for easy handling during painting
Fig. 5.10 A drop of water previews the final appearance of iris colours when sandwiched between the corneal button and the freshly painted iris

Fig. 5.11 Custom-designed metal mould for creating iris/corneal units with four black tinted cold-cure iris blanks ready for turning on a lathe
Fig. 5.12 PMMA blank is turned to the required iris diameter. The pupil is created off-centre using a squared-off drill bit
Fig. 5.13 The iris disc is painted to match the patient's iris
Fig. 5.14 A clear cornea is processed over the painted iris blank and turned to the required iris diameter
Fig. 5.15 It is recommended that the iris is painted under a magnifying lamp
Fig. 5.16 Individual components of the iris
Fig. 5.17 An arcus senilis strongly characterises the appearance of this elderly patient's iris
Fig. 5.18 Polyvinylsiloxane impression taken without an impression tray. Note the shape of the underside of the upper eyelid and the extension under the lower tarsal plate
Fig. 5.19 Ocular impression tray
Fig. 5.20 Disposable syringe used in conjunction with an ocular impression tray
Fig. 5.21 Impression material has been injected into the socket via the hollow stem of the ocular tray
Fig. 5.22 An impression mixing gun with disposable mixing tip and a cartridge containing fast set, heavy body polyvinylsiloxane impression material
Fig. 5.23 The cotton thread embedded in this impression provides an excellent means by which the impression can be retrieved from the socket of a child
Fig. 5.24 The impression is trimmed of excess material and fully immersed in a one-part silicon mould
Fig. 5.25 The impression is removed by sectioning the mould
Fig. 5.26 Preheated white ocular wax is poured into the mould
Fig. 5.27 The wax pattern is cooled down and removed
Fig. 5.28 The anterior surface of the wax pattern is being trimmed to approximate the shape of the anticipated prosthetic eye
Fig. 5.29 The completed wax pattern is ready to be inserted into the eye socket
Fig. 5.30 A backing for the wax pattern is made from shellac base plate. The backing supports the wax pattern during the try-in stage
Fig. 5.31 The wax pattern is tried in the socket
Fig. 5.32 A clear plastic iris/corneal blank is positioned with the rod aligned in central gaze
Fig. 5.33 Matching prosthetic eyes for blind patients can be challenging. This patient's right socket is shallow and small while her left socket is deeper and larger
Fig. 5.34 The rod attaches the iris/corneal unit to the mould
Fig. 5.35 The prosthesis is trial packed with white PMMA
Fig. 5.36 Set up for final iris painting and scleral colouring
Fig. 5.37 The second layer of iris colours being applied
Fig. 5.38 Fine veins are teased from *red* embroidery thread and carefully laid on the sclera in the same manner and amount as observed in the patient's companion eye

Fig. 5.39 A clear veneer of PMMA is then processed over the anterior surface locking in the iris and scleral colours and restoring the cornea to its original shape
Fig. 5.40 The prosthesis is buffed with a wet pumice mix using a calico mop
Fig. 5.41 The fine marks left by the pumice are removed with a polishing compound such as tripoli
Fig. 5.42 Final polishing of a concave posterior surface using a hand-piece and small polishing wheel
Fig. 5.43 The use of pumice, then tripoli and then Kenda 244-Blue to polish PMMA produced surfaces that most resisted the adherence of bacteria compared with other polishing regimes
Fig. 6.1 The cornea may be seen underlying thin conjunctival tissue following a Gundersen flap procedure
Fig. 6.2 Basic prosthetic contact lens designs. (**a**) Occluding pupil mask with clear iris portion. (**b**) Peripheral mask with opaque black pupil. (**c**) Peripheral mask with clear pupil. (**d**) Translucent tinted lens. (**e**) Translucent tinted peripheral mask with clear pupil
Fig. 6.3 Iris flaw following iridectomy. It may be masked with prosthetic contact lens with an opaque peripheral mask and clear pupil
Fig. 6.4 Aniridia. It may be masked with prosthetic contact lens with a tinted or opaque peripheral mask and clear pupil
Fig. 6.5 Corneal leucoma. It may be masked with a prosthetic contact lens with an opaque peripheral mask and a clear or black pupil depending on where the leucomas are located
Fig. 6.6 Full-thickness, total corneal opacity. It may be masked with a prosthetic contact lens with an opaque peripheral mask and a black pupil
Fig. 6.7 Iris coloboma. It may be masked with a prosthetic contact lens with an opaque peripheral mask and a clear pupil
Fig. 6.8 Cataract. A clear prosthetic contact lens with a black pupil improves cosmesis when cataract surgery is not an immediate option and vision is not useful
Fig. 6.9 The *red* appearance as well as the photophobia (both caused by light passing through the iris) may be relieved by fitting a translucent tinted prosthetic contact lens with a clear pupil if the photophobia is moderate or an opaque prosthetic contact lens with clear pupil if the photophobia is more severe
Fig. 6.10 Heterochromia. The colour discrepancy between the two eyes (the affected eye has a grey iris) may be lessened with the use of tinted prosthetic contact lenses or tinted prosthetic contact lenses with clear pupils
Fig. 6.11 Corneal dystrophy. If the eyes are blind and the pupil is not discernable, clear lenses with black pupils will improve cosmesis. If the pupils are discernable and dark, translucent tinted lenses may mask the greyness of the cornea while not compromising the level of vision. Finally, opaque lenses with clear pupils may be a better option than tinted lenses if a wider range of colours is needed and the optimum level of vision is to be maintained

Fig. 6.12 In-house colouring kit for soft contact lenses
Fig. 6.13 This commercially available soft opaque lens with clear pupil does a good job of masking the iris coloboma in this patient's left eye but has an unnatural iris texture
Fig. 6.14 Two examples of soft hand-painted prosthetic contact lenses
Fig. 6.15 Opaque cornea with a smaller palpebral fissure than the companion eye
Fig. 6.16 Distorted cornea following trauma
Fig. 6.17 Left strabismic eye with opaque cornea is masked with a scleral shell prosthesis
Fig. 6.18 Completed medium thickness scleral shell prosthesis
Fig. 6.19 Premanufactured two-dimensional curved iris discs with corresponding corneas
Fig. 6.20 Metal moulds for making two-dimensional curved iris discs
Fig. 6.21 Thin scleral shell design showing relieved areas
Fig. 6.22 Tetracaine or oxybuprocaine anaesthetic eye drops are recommended for patients with clear sensitive corneas
Fig. 6.23 Polyvinylsiloxane impression taken using an ocular impression tray without stem
Fig. 6.24 The two-part mould is ready to be packed with clear PMMA dough
Fig. 6.25 Iris disc painted directly onto the surface of a semitranslucent shell
Fig. 6.26 Iris and scleral colours drying under a lamp
Fig. 6.27 A polyurethane sheet protects the painted surface when a clear PMMA veneer is trial packed
Fig. 6.28 The PMMA veneer is processed according to the manufacturer's instructions
Fig. 6.29 The edges of the hole are smoothed with a cotton thread and pumice
Fig. 6.30 Completed thin scleral shell prosthesis in situ
Fig. 6.31 Rubber suction devices are handy for removing and inserting scleral shell prostheses
Fig. 7.1 This granuloma developed in the inferior bulbar conjunctiva after the patient wore a deep vaulted stock prosthetic eye for many years
Fig. 7.2 Chemosis of the conjunctiva formed under a conformer shell which was inserted following enucleation of the globe 5 weeks previously
Fig. 7.3 Extreme chemosis has developed in this socket due to irritation caused by an extruding orbital implant
Fig. 7.4 The GPC evident under the upper eyelid of this microphthalmic eye has persisted for many years even though the prosthesis has been well maintained and steroid drops have been used regularly to reduce mucoid discharge
Fig. 7.5 Non-retentive contracted socket with a shortage of conjunctival lining and an absence of the inferior fornix
Fig. 7.6 The pressure conformer is held in position by a bandage
Fig. 7.7 An incision is made in the socket, and the scar tissue is released as much as possible
Fig. 7.8 A full-thickness mucous membrane is harvested from the inner lower lip
Fig. 7.9 Full-thickness mucous membrane tissue

Fig. 7.10 The graft site in the lower lip is closed with sutures
Fig. 7.11 The graft is sutured into the surgical defect in the socket
Fig. 7.12 A patient's old prosthesis is placed in the socket and secured with a tarsorrhaphy to stabilise the graft and resist graft contraction
Fig. 7.13 Adhesions are accommodated loosely while the margins extend into the fornix on either side
Fig. 7.14 Sutures hold down a bolster to deepen the inferior fornix
Fig. 7.15 A ridge is added to the front of the inferior edge creating a negative curve
Fig. 7.16 A second method to help resolve lower eyelid laxity is to redistribute pressure from the centre of the lower eyelid to the sides
Fig. 7.17 A strip of the tarsal plate is prepared to reattach the lid to the lateral orbital rim
Fig. 7.18 The sutures are placed through the periosteum of the lateral orbital rim
Fig. 7.19 The tarsal strip secured to the lateral orbital rim
Fig. 7.20 Left eyelid-sparing exenteration for squamous cell carcinoma of the ethmoid sinuses
Fig. 7.21 Custom-made conformer
Fig. 7.22 Custom-made conformer in place
Fig. 7.23 Self-retentive prosthetic eye with satisfactory cosmesis
Fig. 7.24 Retentiveness is enhanced by hollowing the back of the prosthesis
Fig. 7.25 This patient's orbital implant has migrated forwards displacing his right prosthetic eye
Fig. 7.26 This spherical implant has migrated into a superolateral position but is stable behind very thin conjunctival tissue
Fig. 7.27 A migrated but stable Castroviejo orbital implant in medial, central and lateral gaze
Fig. 7.28 The posterior surface is reconfigured to accommodate a migrated orbital implant
Fig. 7.29 Exposed orbital implant
Fig. 7.30 The patch graft procedure begins by freeing the conjunctiva from the implant in the immediate area of the defect
Fig. 7.31 The edges of the detached conjunctiva are draped over the graft and sutured
Fig. 7.32 This right prosthetic eye is made roughly triangular or elliptical in shape, rather than round to prevent rotation within the socket
Fig. 7.33 There are three axes of movement for the prosthesis within the anophthalmic socket
Fig. 7.34 The margins may be trimmed as shown to increase anterior curvature and reduce extensions into the fornices
Fig. 7.35 A gap has opened medially under the prosthesis during abduction of the right prosthetic eye
Fig. 7.36 PMMA material is removed from just behind the edge of the prosthesis so that the edge will settle into closer contact with the conjunctiva

Fig. 7.37 A posterior platform is added to the prosthesis. The platform is designed to prevent backward rotation of the prosthesis, to allow for a narrow lower edge to engage the inferior fornix and to reduce some of the bulk (and weight) of the prosthesis
Fig. 7.38 The conical anterior surface supports and wedges the eyelids apart while minimising the overall bulk of the prosthesis
Fig. 7.39 The four rectus muscles are identified and the intra-conal space is defined
Fig. 7.40 The largest spherical implant that can comfortably be accommodated by the socket is chosen
Fig. 7.41 The implant is placed in the intra-conal space and the rectus muscles sutured to it
Fig. 7.42 Any available remnants of Tenon's capsule are closed in front of the implant, and then the conjunctiva is closed without tension
Fig. 7.43 A temporary tarsorrhaphy is placed to control post-operative conjunctival swelling
Fig. 7.44 Subperiosteal implants are designed to displace the orbital tissues upwards and forwards restoring lost orbital volume and filling out a deep upper eyelid sulcus
Fig. 7.45 Extra bulk added anterior to the superior edge may help correct upper eyelid sulcus deformity and restore the upper eyelid crease
Fig. 7.46 A second ridge in front of the inferior edge, in conjunction with thinning of the *lower edge* from the back, sets the prosthesis upright and counters the potential backward displacement of the bulkier *upper edge*
Fig. 7.47 The prosthetic eye has improved (reduced) this patient's right lower eyelid ectropion
Fig. 7.48 The inward rotation of the eyelashes that is part of upper and lower eyelid entropion has caused an accumulation of mucous on the prosthesis
Fig. 7.49 The convex curvature of the anterior surface is made concave behind the entropic eyelids
Fig. 7.50 This configuration attempts to resolve upper eyelid ptosis by filling the superior fornix and lifting the levator aponeurosis muscle
Fig. 7.51 This patient's ptosis on the medial side of the eyelid causes a marked contour abnormality of the upper lid, drawing attention to the prosthetic eye
Fig. 7.52 A diagonal ridge is added in the location shown by the *dotted line*
Fig. 7.53 A ptosis shelf can be seen on this prosthetic eye. It supports the upper eyelid at its correct height but prevents the eyelid from closing
Fig. 7.54 Exposure of the levator and aponeurosis during ptosis repair surgery. The pink levator muscle can be seen in the middle of the wound, with the white aponeurosis below it and the yellow orbital fat above. The surgical retractors are holding open the orbital septum and orbicularis muscles
Fig. 7.55 A suture is passed through the tarsal plate – usually at the apex of the desired lid contour