INTRAOCULAR LENS IMPLANTATION

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Foreword

Ophthalmology is of course an ancient art which has seemed to have had a life of its own outside the realm of surgery in general—but in recent years such operations as the microsurgical techniques of lens implantation have brought the ophthalmic surgeon closer to the unity which embraces all divisions within the art of surgery.

The pioneering skills of Harold Ridley, Cornelius Binkhorst, Peter Choyce and others have now been brought to fruition by the work of many surgeons throughout the world. The international contributions to this volume attest to the significant developments in very recent years. Intraocular lens implantation techniques are now part of an exact science, applied within the wider field of ophthalmology.

I write as one of the many patients deeply grateful to the distinguished editors of this monograph for their skill and understanding. The few days that I spent in hospital undergoing cataract surgery and lens implantation were for me a new and moving experience. From a long life devoted to the surgery of crippling diseases and injuries I was transported to the country of the blind, the near blind and the potentially blind with all its challenge to surgical science and not least to special nursing techniques.

Modern advances in ophthalmology are exemplified by the techniques discussed in this volume. I trust they will be a source of encouragement to up-and-coming surgeons who in their turn will contribute to the advances of tomorrow.

Sir Harry Platt, Bt, LLD, MD, MS, FRCS

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Preface

The visual needs of patients are dictated by their circumstances, which include age, occupation, leisure interests and independence. As an adviser to a patient, the ophthalmic surgeon must envisage the individual requirements of that patient and balance these against the potential risks of surgical treatment. A surgeon's attitude is dictated by his experience, knowledge of experience of others and confidence in his own ability to achieve the perfection of results that should be his aim.

Patients with visual problems have usually compared notes with friends, or friends of friends, prior to their consultation with the ophthalmic surgeon. More often than not their attitude to treatment is conditioned by the experience of their informants together with knowledge gained from media coverage on advances in medical and surgical techniques.

A trouble-free intraocular lens implant is thrilling in its ability to restore balanced, monocular and binocular visual function without recourse to further intervention. The ability of a lens implant to solve the problem of visual disability caused by incomplete cataract, uniocular or binocular cataracts, is as soon appreciated by the neophyte lens implanter as it is by the successfully treated patient.

The purpose of this volume is to consider, in depth, all aspects of lens implantation. We hope that it will provide the ophthalmic surgeon who intends to commence intraocular lens implantation surgery, with the information necessary for effective and safe participation. For those who are already engaged in this exciting work, we trust that this book will provide a useful source of reference. It is designed to consider both the problem and its solution. The solution has many variations, but all take account of the vulnerable tissues which require to be protected during surgery. Other common ground includes the pre-operative preparation of the patient and postoperative management. Lens implantation in special circumstances and the management of long-term complications of lens implantation are important sections of this volume.

All authors are aware that the production of a volume of this nature takes many months. The subject is developing rapidly, but it is our hope that the wealth of experience incorporated here will be valuable not only in the present but also for some time in the future.

The editors wish to acknowledge their deep gratitude to Mrs. Rita Goggins for her earnest endeavours in ensuring that communications with the contributors were successfully completed and the manuscript retyped for presentation to the publishers; to Geoff Greenwood, formerly of Mosby–Year Book, for his enthusiastic, skillful and dedicated advice in the production of this volume; and finally, to Bob Pearson, whose care and enthusiasm in the editing of the text are deeply appreciated.

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Cataract (from the Greek *katarrhaktes* = portcullis) may be congenital or acquired in origin, unilateral or bilateral in effect. Morphologically, lenticular opacities may be located in the anterior or posterior lens capsule, subcapsular, anterior or posterior, in the cortex or nucleus of the lens. The opacities may take an infinite variety of forms which may progress to complete opacification, to create a mature or hypermature cataract. The effects of lenticular opacities on vision depend on their location within the lens, the size of the pupil and other factors within the eye. The restoration of vision to an eye whose visual acuity is compromised by lenticular opacities has to take into account the effects of the lenticular opacity morphology on visual function and the quality of vision in the fellow eye, the age of the patient, the general medical condition of the patient, etc.

As this volume is concerned with replacement of the cataractous lens by an optically efficient artificial replacement, it is appropriate to initiate these discussions with an account of cataract aetiology and morphology—consideration of the biochemical, local and systemic, physiological and pathological factors that will result in disturbance of vision due to opacification of the lens.

1 Lens physiology in relation to human cataract

GEORGE DUNCAN and JULIA M. MARCANTONIO

INCIDENCE OF CATARACT

Opacification of the lens is extremely common throughout the world, and in the UK accounts for over 20% of those people registered as blind. In old age, the problem becomes much more acute and at 70 years of age, 90% of the total population suffer considerable loss of vision due to lens changes.[1] A more recent statistical survey carried out in the USA has shown that cataract extractions accounted for approximately one-half of all operations for eye disorders in 1972. Although there are approximately 500 000 cataract operations each year, there are still over 1.5 million Americans who have significant visual impairment because of cataract and this represents almost 1% of the total population.[2] The proportion of the population in certain 'third world' countries, who suffer much worse visual impairment, is in fact higher still.[3]

Although cataract is most often an affliction of the elderly, it is also associated with certain medical conditions, including diabetes,[4] hypocalcaemia[5] and uraemia.[6] Cataract can also be initiated by certain drugs including long-acting cholinesterase inhibitors used in the treatment of glaucoma,[7] triparanol, which was used in the treatment of hypercholesterolaemia[8,9] and certain steroid hormones.[10]

Recent studies of cataracts found in cattle have indicated that environmental factors probably play a part[11] and it is suggested[12] that environmental and hygiene factors probably play a role in the very high incidence of cataract found in some developing countries.

The optical clarity of the lens is therefore at risk for a wide variety of reasons and the main aim of this chapter will be to describe the present state of knowledge concerning the normal functioning of the lens in order that the reasons for the great sensitivity of the lens to various insults (including old age!) may begin to be understood.

DEVELOPMENT AND GROWTH

Morphology

Introduction

In vertebrates, the crystalline lens is of purely ectodermal origin and forms from the head ectoderm overlying the presumptive optic vesicle of the neural crest. In the human embryo, the primordia of the optic vesicles establish contact with the overlying head ectoderm at about the 2.5 mm stage *(Figure 1.1a)* and by the 4.0–4.5 mm stage the ectoderm has thickened to form the lens placode *(Figures 1.1b* and *1.1c)*. Both optic vesicle and lens placode then invaginate, the former to become the optic cup, the latter to form a sac-like lens vesicle which is pinched off from the head ectoderm *(Figures 1.1d–1.1f)*.

Epithelium and fibres

The next stage in development involves the elongation of the cells of the posterior part of the lens vesicle to form primary lens fibres *(Figures 1.2a–1.2c)*. This elongation gradually occludes the lens cavity until, in the 25 mm embryo *(Figure 1.2c)* the lens consists of a single layer of epithelial cells covering the anterior half of a compact body of primary lens fibres, which persist as the embryonic nucleus. From this stage the lens can be regarded as consisting of two functionally distinct regions or compartments which coincide approximately with the physical separation of the anterior and posterior parts of the lens by the border of the optic cup.

Embryonic development continues by increase of cell numbers in the anterior proliferation compartment, especially in the equatorial or bow zone, and differentiation of cells from the bow zone to form secondary lens fibres in the posterior elongation compartment. As each fibre differentiates the cell elongates, loses its nucleus, becomes optically clear and begins to produce crystallins, the characteristic lens pro-

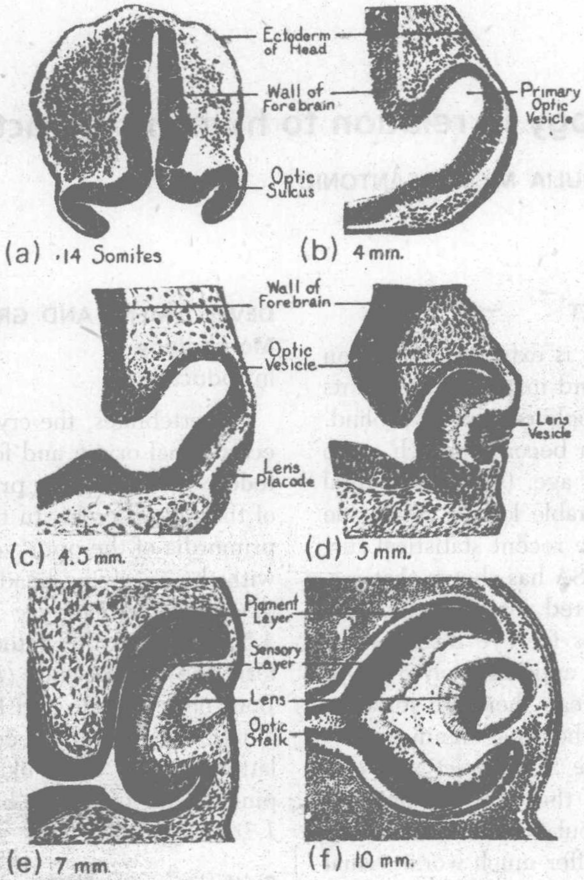

Figure 1.1 *Early stages in the development of the human lens* (×100) *as shown in axial sections* (Courtesy Dr L.B. Arey[13]). (a) The first indication of the optic vesicles, even before the forebrain is a closed tube; (b) in the region of an optic vesicle the overlying ectodermal epithelium is beginning to thicken into a lens placode; (c) the lens placode is thicker and better delimited; (d) the placode is invaginating to form a lens vesicle and the optic vesicle is beginning to form an optic cup; periderm cells occupy the concavity of the unclosed lens vesicle; (e) the lens vesicle is a sac, about to detach from the ectoderm at the site of the lens pore; (f) the lens vesicle is free and closed; cells in its back wall are elongating into early primary lens fibres

teins. Secondary fibres are produced in concentric layers round the embryonic nucleus (*Figure 1.2c*). Each fibre elongates from the equator towards the poles of the lens and where the many fibres of each layer meet suture lines form. These are, at first, simple Y-shaped structures but become more complex as the lens changes shape and in the adult have a starred configuration. The equatorial growth is also responsible for the change in shape of the lens which, by term, has become characteristically disc shaped, with the posterior surface considerably more convex than the anterior.

Capsule

Secretion of the lens capsule begins at about the 13 mm stage of human embryonic development, but is said not to encapsulate the lens completely until mid-term.[13] The capsule is slightly elastic in nature and, at term, is of the order of four times thicker on the anterior surface of the lens than on the posterior side. It is a regularly laminated structure, as seen in electron micrographs, which is produced by successive depositions of collagen-based material by the epithelial cells. This process has been clearly demonstrated by Young and Ocumpaugh,[14] who