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Rhegmatogenous Retinal Detachment: A New Zealand Perspective.

Philip John Polkinghorne

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Medicine, The University of Auckland, 2007.
ABSTRACT

In New Zealand, rhegmatogenous retinal detachment (RRD) is recognised as a serious and potentially blinding disorder but little is known about the prevalence, risk factors, management and outcomes for treatment for our population.

This thesis attempts to investigate these issues and part of that documentation involved a clinical review of those individuals presenting with RRD. That survey was performed over a 16 month interval enabling the annualised rate for individuals presenting with a new RRD to be determined. The prevalence was found to be 11.8 per 100,000. The risk was age-related with the incidence of RRD increasing for each decade up until the age of 70 years. Men had a slightly greater risk of RRD, and high myopes (greater than 6 dioptres) accounted for approximately 1/3 of the presentations. A history of cataract surgery was also noted to be a significant risk factor for RRD.

A subsequent investigation documented in this thesis determined the rate of RRD following cataract surgery using phaco-emulsification techniques was 1%. The risk for pseudo-phakic patients was inversely related to age.

The initial survey revealed approximately 2/3 of the patients presented with macula-off RRDs. While individually many of these patients did well, as a group the functional improvement following surgery was limited and less than 1/3 of eyes achieved LogMAR 0.3. It was not always apparent what factors negatively impacted on the functional prognosis but certainly those individuals requiring more than one surgery tended to fare worse.

The impact of a poor visual outcome was not directly assessed in this thesis but it is likely those individuals do suffer in terms of visual functioning and quality of life issues. In New Zealand there are a number of agencies that care and support visually impaired persons but there is
inadequate data to assess and benchmark treatment and rehabilitation. If this could be achieved for patients with RRD then those barriers which potentially restrict successful outcomes might provide useful insight for other individuals with visual impairment.
ACKNOWLEDGEMENTS

There are a number of friends and colleagues who have encouraged me in this project; to learn, to think, to assimilate and finally to commit. I have been fortunate to receive advice and mentoring from Jennifer Craig and Sue Ormande as well as the considerable resources within the Department of Ophthalmology at the University of Auckland. Andrea Vincent spent time and energy challenging me to evaluate the nemesis that is the world of molecular biology. To all these people I am grateful but I remain deeply indebted for the support of my wife, Pauline Hanna who has really made this achievement possible.
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<tr>
<td>ACC</td>
<td>Accident Compensation Corporation</td>
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<td>AMD</td>
<td>Age Related Macular Degeneration</td>
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<td>ANOVA</td>
<td>Analysis of variance</td>
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<td>BCVA</td>
<td>Best corrected visual acuity</td>
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<td>VF-14</td>
<td>14-Item Questionnaire of Visual Function</td>
<td></td>
</tr>
<tr>
<td>$</td>
<td>Dollar</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>$\mu m$</td>
<td>micrometres, $10^{-6}$ m</td>
<td></td>
</tr>
</tbody>
</table>
Section I:

Introduction
Chapter 1: Introduction to Rhegmatogenous Retinal Detachment.

Rhegmatogenous retinal detachment (RRD) remains an important cause of ocular morbidity accounting for more than 200 ophthalmic procedures per year at Auckland City Hospital and more than 1000 outpatient visits. Whilst this number is not large in absolute terms, the impact of this diagnosis for the affected individual can be dramatic. An acute RRD is a threat to vision and, although treatment is often successful, there is an ongoing risk of recurrent detachment in either the presenting or fellow eye. (1-3) Surprisingly, the effect on an individual being confronted with visual loss has only been recently addressed, and to date very limited research has been performed on patients experiencing this threat from retinal detachment.

1.1 Quality of Life Indicators.

The Melbourne Visual Impairment Study investigated the effect of both unilateral and bilateral visual loss on an individual’s quality of life and found a reduction in visual acuity adversely affects participation in social and religious pursuits, as well as mobility and normal activities associated with day to day living.(4) The Melbourne study was a population based study, designed to be representative of contemporary Australia in the late 20th century. As such, the results reflected the demographics of the population as a whole and may not be entirely relevant to patients with retinal detachment.(5) However, this study did find that non-correctable unilateral visual loss compromised safety and personal independence, while bilateral visual loss was more likely to adversely affect emotional wellbeing, require nursing home placement and increased reliance on community services. (6,7)


1.2 Quantifying Visual Loss.

While it may appear there is great diversity in assessing the physical, social and emotional aspects of visual loss, there are vision-specific quality of life (QOL) indicators which are useful in quantifying the degree of impairment.\(^8\) In the ophthalmic literature there are a number of quality of life questionnaires or *instruments* that have been designed to assess patients' wellbeing. Typically, the ophthalmic based instruments contain questions or *items* related to objective psychophysical assessments such as visual acuity or visual fields. Such indicators have the advantage of evaluating the overall wellbeing of an individual without the disadvantages of a time-consuming generic assessment. Furthermore, if there are sufficient general health related QOL indices incorporated in a questionnaire, then comparisons can be made with other non-ophthalmic disorders.

In ophthalmology, the most widely used QOL instrument is the VF-14.\(^8\) This 14-item instrument was developed to evaluate visual morbidity associated with cataract patients, but has since been utilised in the assessment of other ophthalmic disorders including retinal pathologies.\(^9,10\)

The VF-14 instrument has been criticised for placing too much weight on visual functioning and ignoring other indicators of wellbeing.\(^11\) Accordingly, other instruments have been introduced that take into account other indicators including physical and mental health, extent of functional impairment and degree of social functioning. One of the instruments that has been used in the assessment of patients with retinal diseases is the Short Form-36 (SF-36).\(^12\)

The SF-36 contains 36 items designed to evaluate conceptual areas of wellness including: general and perceived health, emotional wellbeing, ability to perform standardised physical tasks, limitation of daily activities, and quantification of pain if present. The results of the SF-36 can be used to generate two composite scores, assessing both physical and mental wellbeing. The physical component score (PCS) and the mental component score (MCS) can
be then compared to normalised data based on a reference population. The mean score of the reference population is 50 and the standard deviation 10. Higher scores indicate better health.\(^8\)

Globe et al \(^{13}\) have assessed the validity of the SF-36 for a variety of retinal diseases and determined statistical differences exist between the mean QOL scores across a range of retinal diseases. \(\text{(Table I-1)}\)

A secondary outcome of that study was the finding that patients with acute retinal conditions, including those with retinal detachments, had the lowest mean component scores with respect to mental wellbeing. Conversely, patients with aged related macular degeneration (AMD) and diabetic retinopathy, while reporting lower physical component scores, appeared to accommodate more ably than those patients with retinal detachments. Furthermore, there is evidence to suggest that the mental wellbeing of patients with AMD does not decrease with time and surprisingly has little association with changes in acuity. \(^{14}\)

\begin{table}
\centering
\begin{tabular}{|l|c|c|}
\hline
Retinal Pathology & PCS-36 & MCS-36 \\
\hline
Posterior vitreous detachment & 50 & 53 \\
Rhegmatogenous retinal detachment & 49 & 48 \\
Diabetic retinopathy & 46 & 51 \\
Age-related macular degeneration & 48 & 49 \\
\hline
\end{tabular}
\caption{Component Scores for a variety of retinal conditions utilising the SF-36 instrument, assessing both physical and mental wellbeing. Scores range from 0 to 100; higher scores represent better perceived health.}
\end{table}

PCS = physical component score; MCS = mental component score.

\textit{From Globe et al 2002.}
The impact of successful intervention on patients presenting with RRD has also been assessed using patient questionnaires and shown to correlate with outcome.\(^{(15)}\) Whilst this does not necessarily validate intervention from a societal perspective, it does demonstrate a benefit for the individual patient. The economic benefit, however, can be determined provided the cost of that intervention is known and there is a measurable output index.

### 1.3 Cost Utility Modeling.

Cost utility modeling can determine the value of medical interventions, including retinal reattachment surgery, by assessing the potential benefit in terms of either quality of life or life expectancy and the costs associated with that intervention. The parameter Quality Adjusted Life Year (QALY) combines both of these indices and so facilitates an evaluation of both quality as well as life expectancy. Typically, life expectancy is determined from standard life tables, whereas the life quality component is based on a determination of what is perceived to be an ideal state of wellness.

A number of approaches have been used to generate such quality of life valuations which is in essence a quantitative assessment of an individual’s preferences regarding the quality of life associated with a particular health status. Two methods of preference evaluation widely used include time trade-off and the standard gamble.\(^{(8, 16, 17)}\) Both methods require the individual to state what they would sacrifice to achieve a certain health status and have been shown to correlate closely with the acuity in the better-seeing eye.

In addition to time trade-off and standard gamble, other utilities have been investigated and validated for ophthalmic patients.\(^{(18, 19)}\) However what is almost universally accepted is that the determinant of wellness should lie on the continuum between 0 and 1, where 0 is equivalent to being dead and 1 represents the best possible state of wellness.\(^{(20, 21)}\)
There are two major applications of QALYs in cost utility analysis. The first provision is to provide a framework to evaluate various therapeutic interventions in terms of health utilities, while the second application is to determine the costs of treatment in terms of QALYs gained. It is possible to verify the amount of time spent in a particular wellness state from clinical practice and then index that period against the utility score given to that wellness state. For example, 1 year of perfect health or wellness when the utility score is 1 would net 1 QALY. Equally, it is possible to determine the relative merits of certain treatment interventions in terms of QALYs. (Table 1-2)

**Table 1-2: Calculating QALYs: an example.**

<table>
<thead>
<tr>
<th>Intervention A: Four years in wellness state 0.75</th>
<th>3 QALYs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention B: Four years in wellness state 0.5</td>
<td>2 QALYs</td>
</tr>
<tr>
<td>Additional No. of QALYs generated by Intervention A</td>
<td>1 QALY</td>
</tr>
</tbody>
</table>

In terms of evaluating treatment costs, the unit is typically defined in terms of QALY gained. This measure is expressed as $/QALY gained and can not only compare treatment options in dollar terms but provide an index for determining health care benefits relative to health care expenditure. It is generally accepted that procedures that cost less than US $50,000 per QALY are cost effective.\(^{(22, 23)}\)

Brown et al.\(^{(24)}\) performed a cost utility analysis for complicated retinal detachment and determined that in this subgroup of patients, where the functional result is often limited, a cost effective benefit exists. The analysis was conducted assuming the mean age of the patient group was 64 years, with a life expectancy of 18 years. The model based the presenting visual acuity and final visual result on indicative values determined from the Silicone Oil Study.\(^{(25)}\)
That study explored the outcomes of silicone oil as compared to sulphur hexafluoride in the management of RRD complicated by advanced proliferative vitreo-retinopathy (PVR). A secondary outcome was to provide relevant indicators for determining subsequent interventions such as removal of silicone oil and cataract surgery.\(^{(26)}\) Incorporating these and other variable costs into the cost utility model yielded a US$/QALY ratio of between $40-$62K. This range compares favourably with other medical interventions such as treating systemic hypertension, asthma, and joint replacement surgeries.\(^{(27,28)}\)

### 1.4 Cost Utility Analysis of RRD.

Cost utility analysis may also be useful in determining the most cost effective treatments.\(^{(29)}\) To date, only one such analysis has been performed in a study comparing methods of retinal re-attachment.\(^{(30)}\) The outcome of that study did not determine the $/QALY ratio, but compared two treatment modalities in terms of quality adjusted life months (QALMs), the implication being the that treatment producing the greater QALM would be the preferred utility. The treatment options evaluated were pneumatic retinopexy and scleral buckling which are able to be directly compared as the functional and anatomical outcomes of these approaches are similar for uncomplicated RRD. The QALM index was determined by comparing the pre- and post-operative acuity for each treatment and demonstrated a relative benefit of 1.86QALMs for pneumatic retinopexy over scleral buckling, representing a 7.4% differential in favour of pneumatic retinopexy. While this does not indicate pneumatic retinopexy is universally superior to scleral buckling, it does imply that under certain circumstances a benefit does exist for the patient.
1.5 Impact of Visual Impairment in New Zealand.

To date, health economic models have been largely developed in the anticipation that a rationale for estimating and comparing costs of intervention will emerge.\(^{(28, 31)}\) However, for a model to be fully functional, the costs of under-resourcing and/or delaying active treatment need to be included. In Australia, the economic impact of under-treatment of visual impairment has been calculated at $5.0 billion dollars or 0.6% of GDP.\(^{(32)}\)

Comparable figures are not available in New Zealand, but in 2001 Statistics New Zealand conducted a Household Disability Survey and assessed adult New Zealanders with a seeing or vision disability.\(^{(33)}\) Visual impairment was defined in this survey as an inability to view ordinary newspaper print or the face of a person across a room. Based on this definition an estimated 60,900 adults or 2% of the adult population had a seeing disability. Men comprised 40 percent of adults with seeing disability (27,800 individuals) and women 60 percent (41,500 individuals).

Age-specific rates of seeing disability were higher in the older adult age groups and highest in the 75 and over age group, with more than 1 in every 10 people aged 75 and over (12,400 per 100,000 population) having at least one kind of seeing limitation. More adults were categorised as having difficulty seeing newspaper print as opposed to those having difficulty seeing someone’s face across the room, that is at a distances of 4 metres (12 feet). (Table 1-3). Unfortunately this disability survey did not address the cause of visual disability nor did it indicate treatable causes of visual loss.
Table 1-3: Categories of visual impairment reported by adults living in New Zealand households, 2001.

<table>
<thead>
<tr>
<th>Category of visual impairment</th>
<th>Estimated absolute number of adults in New Zealand per category.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can see newspaper print, but with difficulty</td>
<td>52,200</td>
</tr>
<tr>
<td>Cannot see newspaper print</td>
<td>8,700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60,900</strong></td>
</tr>
<tr>
<td>Can see someone’s face across the room, but with difficulty</td>
<td>24,200</td>
</tr>
<tr>
<td>Cannot see someone’s face across the room</td>
<td>6,700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30,900</strong></td>
</tr>
</tbody>
</table>

Note:

i) If individuals reported more than one category of seeing disability, they were counted in each applicable seeing disability category.

ii) The sum of the values for each category may differ from the total due to rounding.

*Source: Statistics New Zealand, 2001 Household Disability Survey.*

Other potential sources for determining the extent of visual impairment in New Zealand include the Royal Foundation for the Blind, the New Zealand Health Information Service and Accident Compensation Corporation (ACC). Regrettably, the data collated by all these bodies is incomplete and, in the case of the ACC statistics relating to visual loss resulting from accidents, are limited to those claimants where entitlement is established. In practice this means ACC does not collect data on patients if the period of incapacity is less than one week and/or the patient has been managed in the public sector.

The Royal New Zealand Foundation for the Blind collects data on every new registrant, but as registration is voluntary, the true extent of visual loss from RRD is likely to be under-represented. Furthermore, registration is limited to patients who have bilateral visual loss and approximately one third of members do not have an ophthalmic diagnosis. It is estimated that approximately half of the persons legally blind in New Zealand are not registered with the
Of those 11,315 registered members of the Blind Foundation, 34 are said to be blind from RRD.

The New Zealand Health Information Service (NZHIS) is a division within the Ministry of Health that is charged with recording the admitting diagnosis, as well as any co-morbidity, for all patients admitted to public hospitals. The diagnostic indices used are selected from categories as detailed by the International Classification of Diseases (ICD), the latest revision being ICD-10. Demographic data is also recorded for each hospital admission, as well as the mean length of hospital stay. The most recent data published by the NZHIS is for the 2000/01 financial year. During that 12 month period, 189 patients were coded as having a retinal detachment with a retinal break (ICD-10: H33.0). One hundred and twenty six of the admissions were male, while 63 were female. The mean hospital stay was 2.4 days although 27 patients were day-stay admissions. The peak incidence for retinal detachment occurred in the 65-70 year age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Absolute Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>0 0 1 5 10 7 12 10 12 13 18 21 27 21 14 3 6</td>
</tr>
</tbody>
</table>

Source: NZHIS (2000/01)

The integrity of this data is unfortunately questionable and an internal audit at Auckland City Hospital for the period under review found approximately 10% of patients with RRD were miscoded. The misdiagnoses included serous retinal detachment (ICD-10: H33.2), tractional retinal detachment (ICD-10: H33.4) and other retinal detachment (ICD-10: H33.5). These
diagnostic indices are included in the NZHIS database and a further review of this database suggests the miscoding seen at Auckland City Hospital has been repeated nationally. For example, experience suggests the commonest cause of tractional retinal detachment in New Zealand results from diabetic eye disease, yet when the co-morbidity diabetes mellitus is searched for in this subset, half of those patients with TRD are diabetics. (NZHIS 2000/01). Similarly, the mean hospital stay was 1.7 days for 319 patients coded with serous retinal detachment during the period under review. Given that most patients with serous retinal detachment have central serous retinopathy, which only in exceptional circumstances results in a hospital admission, it is likely that many patients with this diagnosis were incorrectly coded.

The absence of accurate information for any disease causing significant morbidity is of concern and limits the basic requirement of a health system to respond appropriately, matching resource with need. Without robust information there is a risk of either under resourcing, or over supply, of both staff and expenditure. Certainly there is a need in New Zealand to improve the reporting standards for patients with retinal detachments. Indeed, translation research applied to RRD may provide a suitable model for public health planners and policy makers to implement cost effective interventions for both treatment and rehabilitation. Such an approach might also identify those barriers which potentially restrict successful outcomes and so provide a basis for reviewing and auditing health care delivery in New Zealand.
1.6 References.


Chapter 2: Anatomy, Physiology and Pathogenesis of Rhegmatogenous Retinal Detachment.

Rhegmatogenous Retinal Detachments (RRDs) are an uncommon cause of visual morbidity. \(^{(1)}\) The events leading to retinal detachment are poorly understood but involve sequential and concurrent pathways from vitreous separation, induction of retinal tears or breaks and accumulation of fluid under the retina. \(^{(2)}\) A review of the relevant ocular anatomy/physiology and the current literature in relation to rhegmatogenous retinal detachment will highlight issues which are pertinent to the current thesis and may be important for future research.

2.1 Anatomy of the Eye.

The human eye approximates an asymmetrical sphere and comprises an outer, predominantly collagenous layer consisting of sclera and cornea. The cornea accounts for approximately 1/6 of the surface area and is located anteriorly. The internal aspect of the sclera is lined with a vascular layer called the uvea that extends anteriorly to the zone where the cornea merges with the sclera. The uvea is subdivided into the choroid posteriorly, while more anteriorly the terms pars plana, pars plicata and iris are used, reflecting the changing structural and functional role of the uvea. The innermost layer of the eye is called the retina and this structure forms a continuous layer on the internal aspect of the uvea extending anteriorly to the pars plana. The term used to detail the most anterior extent of the retina is called the ora serrata. The ora serrata extends slightly more anteriorly on the nasal aspect of the globe.
2.2 Components of the Vitreous.

The vitreous is a gel comprised mainly of water but contains other important structural components including hyalocytes, collagen, the glycosaminoglycans hyaluronan and chondroitin, as well as glycoproteins and other low molecular weight compounds. Collagen is present in at least three forms in human vitreous, types II, IX and XI. Type II makes up 80% of the total vitreous collagen while the lesser type IX molecule is covalently bound to chondroitin, enabling it to assume a proteoglycan form. Type XI collagen has an important function in regulating the diameter of collagen fibrils and up-regulation of the genes controlling this protein results in fibrils with a smaller diameter. The vitreous accounts for about 80% of the volume of the eye and consists of an outer or cortical layer and central component sometimes referred to as the body or corpus vitreous. The vitreous cortex is not a uniform layer but exhibits regional anatomical variations which are thought to have
functional significance. In the zone adjacent to the ora serrata and pars plana the collagen fibres of the vitreous cortex are denser than elsewhere and merge to become an integral part of the ora and pars plana. This zone is called the vitreous base. The vitreous base extends posteriorly with age as additional peripheral vitreo-retinal inter-digitations develop. Elsewhere, the peripheral cortical vitreous is more loosely adherent to the retina, although stronger attachments are typically seen over the retinal vessels and around the optic nerve. However the exact nature of these attachments can vary with age and disease.

2.3 Relationship of Neuro Retina and Retinal Pigment Epithelium.

The interface between the choroid and retina is clearly demarcated by the pigmented retinal pigment epithelium (RPE) which microscopically can be shown to have an intimate connection with a complex membrane called Bruch’s membrane. Conversely, the relationship between the RPE and the photoreceptors which approximates the apical surface of the RPE has a less adherent attachment. There are a number of pathological processes that can lead to a separation at this junction and the generic term “retinal detachment” is often used to describe this entity.

The other cellular elements comprising the retina consist of neural and connective tissue-like elements and are arranged in an orderly fashion giving the appearance of being laminated when viewed with a light microscope. (Figure 2-2)

The nuclei of the photoreceptors are grouped in the outer nuclear layer while cellular extensions approximating the RPE comprise the outer segment layer. The axonal projections extending from the photoreceptor nuclei make up the outer plexiform layer, and form connections with the horizontal and amacrine cells. The nuclei of these cells, together with the vertically orientated bipolar cells, form the inner nuclear layer. These cells in turn interface
with the ganglion cell layer at the inner plexiform layer. The ganglion cell axons form the nerve fibre layer and exit the eye as the optic nerve.

In eyes with retinal detachments, histopathological changes can be found in all the layers of the retina but the earliest and most severe changes can be seen in the photoreceptors and RPE. (17)

**Figure 2-2: Histological preparation of normal retina.**

The cell type and relationships of cellular elements are highlighted in black.

*Slide Courtesy of Professor John Marshall, London, U.K.*

The retina does exhibit regional variation and alterations in cell type and content lead to differences in retinal thickness. The thickness of the retina is greatest temporal to the optic...
nerve approximating 360μm.\(^{18}\) The retina becomes thinner peripherally and again at the posterior pole where the macula is located. At the macula, the retinal vasculature is absent and the cellular elements are restricted to photoreceptors and their cellular processes comprising the Henle fibres.\(^{19}\) The Henle fibres are orientated obliquely and extend to the inner nuclear layer. The retinal thickness at the macula is approximately 250μm.

*In vivo* measurements of retinal thickness can be made using optical coherence tomography (OCT). This device produces real time, cross-sectional images of biological tissues and is particularly well suited for imaging the retina. The principle of OCT is analogous to ultrasound imaging except light rather than acoustic waves are utilised to construct an image. This is achieved by passing coherent light into the eye and comparing the reflected light with a reference light in terms of spatial and temporal parameters. The axial resolution of OCT imaging is inversely proportional to the bandwidth of the light used for imaging. The light source utilised in the Stratus OCT \(^\text{TM}\) (Zeiss, Germany) has a band width centred at 800nm and is capable of axial resolution approximating 10μm.\(^{20}\)

**Figure 2-3:** Optical Coherence Tomography (OCT) of the posterior pole.

The thickness of the macula in this patient approximates 225μm.
2.4 Physiology.

The dioptric elements of the human eye enable visible wavelength light to be focused on the retina. There are 2 main classes of photoreceptors; rods and cones. Rods and cones differ in terms of their response to certain wavelengths of light as well as sensitivity to light. These differences relate to the pigment type in their outer segment; rods contain rhodopsin while the cones may contain one of 3 opsins or pigments which are variably sensitive to red, green and blue light. The spectrum of sensitivity means that electromagnetic radiation between 400 and 700nm is seen as visible light. Exposure to light of these wavelengths induces conformational changes in the opsin, which in turn initiates electrical activity in adjacent retinal cells culminating in the transfer of information to the ganglion cell fibres and hence to the optic nerve.

A considerable amount of signal processing occurs in the retina facilitating the transference of information gleaned from approximately 130 million rods and 6 million cones to the 1 million fibres comprising the optic nerve. Much of this signal processing remains unknown, but both inhibitory and excitatory mechanisms are involved in the postsynaptic receptors. These receptors include the horizontal, bipolar, amacrine and ganglion cell types. While exposure to light hyperpolarises the photoreceptors in series of graded shifts, subsequent responses are modulated by bipolar cells which in turn signal the ganglion cell. Furthermore, the photoreceptors can be interlinked by horizontal and amacrine cells and act regionally to modify the signal to the ganglion cells.

More complex responses mediated by the ganglion cell type depend on the extent of the receptor field impinging on that cell, and whether the ganglion cell responds to a central dark or light region. Other spatial summations and chromatic sensitivities have also been described.
The influence of ganglion cell physiology in determining a variety of visual features depends on the unique ability of the photoreceptor to present sufficient opsins to respond to lighting conditions over a wide range of luminance. A degree of sub-specialisation has evolved between the photoreceptors, and at low levels of luminance the rods are more responsive than cones. Conversely, under normal daytime levels of light, the cones are more sensitive. Further task differentiation is illustrated by the rods being involved in movement detection, while the cones enable fine discriminatory visual tasks to be performed. The visual processing of the cones is further enhanced by their concentration at the macula. This area is largely devoid of other retinal elements and retinal blood vessels. The absence of a retinal circulation at the macula necessitates an interchange of substrates and byproducts through the RPE to the choroidal circulation. Thus any separation of the RPE and neural retina at the macula, as may occur in a RRD, can have an adverse effect on the integrity of the macular photoreceptors as well as the RPE. (27, 28)

2.5 Changes in the Retina Associated with Rhegmatogenous Retinal Detachment.

The pathological changes following retinal detachment are not restricted to the macula and widespread changes can be seen in all the retinal layers. (27) At a sub-cellular level, metabolic and biochemical changes occur whilst the disruption of the photoreceptor - RPE interface enables a protein-rich solution to permeate the sub-retinal space. (29) The surgical repair of RRD can reverse many of the pathological changes noted during retinal detachment, although the functional prognosis depends on the status of the macula at the time of the surgery. (30) Retinal detachments involving the macula typically have a worse functional result than those eyes where the macula remains attached. The visual outcome of macula-off detachments is also influenced by the height of the detachment as well as the duration. (30, 31)
Wolfensberger has also shown that in macula-off retinal detachments the delay in visual recovery can be due to persistent sub-retinal fluid at the macula and this may be related to the surgical technique.\(^{(32)}\) Nevertheless, macula function does not usually return to normal, even if the macula is successfully re-attached with surgery.

It is believed that in part, some of these irreversible changes are accounted for by persisting abnormalities in the macula outer segments and discs, together with structural changes in the cilia. These changes are more prominent in eyes with chronic retinal detachments and are often accompanied by generalised retinal atrophy together with pigment epithelial alterations.\(^{(33)}\) However, even in macula-off detachments the visual function can continue to improve following successful re-attachment of the retina. Hayashi and others have shown that both colour vision and the cone electro-retinogram can improve for up to 12 months following surgery.\(^{(34)}\) This recovery may in part be due to re-growth and re-alignment of photoreceptor outer segments together with metabolic recovery of the retinal pigment epithelial photoreceptor complex.\(^{(35)}\)

### 2.6 Facultative Events in Development of a Rhegmatogenous Retinal Detachment.

In developing a comprehensive theory to explain the sequence of events leading to a RRD, it is conceptually useful to consider both the pathological features associated with RRD as well as the dynamic changes that might precipitate or accompany a RRD. The former includes the presence of a retinal break, serous fluid in the sub-retinal space, and altered vitreous typically clinically recognised as a posterior vitreous detachment (PVD).

Other pathological entities may also accompany a RRD, such as the presence of blood and/or pigment granules in the vitreous gel. Similarly, anomalies or abnormalities of the retina may co-exist with RRD and include such clinical features as lattice degeneration, cystic
degeneration and retinal folds. While these latter findings are frequently documented they are not considered either absolute or facultative requirements for RRD.\(^{(36)}\)

In most eyes the cardinal event thought to precipitate RRD is the development of a PVD. The events leading to a PVD are poorly understood but are believed to result from alterations in the ultra-structure and interaction of the molecular and supra-molecular components of the vitreous.\(^{(16,37)}\)

Balazs developed a model of the vitreous that attempted to explain how the vitreous might undergo liquefaction suggesting the vitreous was structured on a matrix of collagen fibrils with hydrated hyaluronan immersed in the fibrils.\(^{(38)}\) This model relied on a sparse and random network of collagen fibrils but recent studies have suggested, using rotary shadowing and electron microscopy, that there are physio-chemical linkages between the collagen fibrils and the component glycosaminoglycan molecules.\(^{(39)}\) Scott has expanded on this concept and measured the separation of the collagen fibrils.\(^{(10)}\) He noted that although the fibrils could be arranged in sprays and sometimes parallel bundles, the essential feature was the fibrils were spaced at discrete intervals. Indeed the spacing of the fibrils mimicked that seen with the corneal stroma, albeit a very watery one. Scott maintains that the vitreous gel consists of a three component complex of collagen-glycosaminoglycan-hyaluronan.\(^{(10)}\) (Fig 2-4)
Figure 2-4: Ultra-structure of vitreous.

In this model the proteoglycan molecules, consisting of chondroitin and type IX collagen, form cross-links with type II collagen fibrils, which in turn are related to hyaluronan. This arrangement allows for the formation of an infinite meshwork.

Slide from Scott, 1992.
For a PVD to occur the vitreous must undergo liquefaction and typically this commences in the central areas of the vitreous gel.\(^{(40)}\) The process of liquefaction is not well defined but a number of mechanisms are thought to be involved, including an age-related decrease in the density of collagen fibrils, migration of hyaluronan molecules, alteration in the tertiary structure of collagen, and development of abnormal molecular cross linkages.\(^{(41-45)}\)

The events leading to liquefaction appear to produce a domino effect on the surrounding vitreous gel, ultimately leading to the separation of the vitreous from the post-equatorial retina.\(^{(46)}\) As the vitreous separates from the post-equatorial retina, liquid vitreous passes through defects in the vitreous cortex and so enters the retrocortical space.\(^{(47)}\) It is believed liquid vitreous in the retrocortical space together with ocular movements contribute to the progressive separation of the vitreous from the retina so leading to a complete vitreous detachment.\(^{(43)}\) Clinically, the pathognomonic sign of a PVD is the presence of a Weiss ring. This has been shown histologically to represent peripapillary glial tissue.\(^{(48)}\)

The ultra-structural changes occurring during PVD can be shown to involve a dehiscence at the level of the vitreous cortex and internal limiting membrane of the retina (ILM). However, both scanning and transmission electron micrographs have revealed variations in this plane of cleavage implying that during the evolution of the PVD, components of the ILM may remain adherent to the vitreous cortex. Indeed, in younger individuals it appears that adherence of the ILM to the posterior vitreous cortex is the norm.\(^{(15, 49)}\) It had been previously thought that vitreous collagen fibrils inserted into the ILM, but the absence of type II collagen in the ILM makes this unlikely.\(^{(49)}\) Instead the integrity of the vitreos-retinal interface is believed to be at least in part maintained by an extra-cellular matrix.\(^{(43, 50, 51)}\) Recent studies have identified candidate macromolecules including galactose \(\beta (1,3)\)-N-acetyl-glucosamine.\(^{(52)}\)
Interestingly, while this macromolecule has been found in the ILM of young donor eyes, it was absent in those eyes from donors aged 58 years and older. This finding, together with the known regional variations in the ILM in primate eyes, raises the possibility that temporal alterations in the vitreo-retinal interface may facilitate the development of posterior vitreous separation in aged eyes.\(^{(53)}\)

### 2.7 Anomalous Posterior Vitreous Detachment.

*In vivo* studies using OCT have also highlighted that variations can occur during separation of the posterior hyaloid\(^{(54, 55)}\) It is believed at least some of the so-called anomalous vitreous detachments are thought to play a role in the pathogenesis of such posterior pole pathology as cystoid macular oedema, vitreo-retinal traction syndromes, epi-retinal membrane formation and macular holes\(^{(49, 56, 57)}\).

**Figure 2-5: OCT of the posterior pole demonstrating complete posterior vitreous detachment.**

\[\text{Figure 2-5: OCT of the posterior pole demonstrating complete posterior vitreous detachment.}\]

\[\text{= enhancement to show detachment}\]
2.8 Retinal Breaks with Traction.

Most retinal breaks are believed to occur during the development of a PVD when the normal physiological separation of the vitreous cortex from the retina encounters abnormal or pathological areas of vitreo-retinal adherence. Such areas are commonly seen over retinal blood vessels and at the posterior margin of the vitreous base. The former may explain the propensity for vitreous haemorrhage to occur even in eyes with an apparently uncomplicated PVD. Foos has noted in post mortem eyes that, provided the vitreous base has a smooth posterior border, any tractional forces developed during or following a PVD are unlikely to produce a retinal tear. Conversely, posterior extension of the vitreous base can predispose to the formation of retinal tears. (Fig 2-7)
The posterior extension of the vitreous base can predispose to the formation of peripheral retinal tears.

Figure 2-7: The posterior extension of the vitreous base can predispose to the formation of peripheral retinal tears.

*From Foos (1972).*

This observation of Foos can be mathematically determined by measuring the tensile elastic modulus of the retina. This value, also called Young’s modulus, provides an index for a material to resist tearing and is defined by the ratio of force per unit area and change in length induced by that force. While Young’s modulus holds for perfectly elastic materials, the concept can be applied to the retina if certain approximations are made. Jones and Wu have independently calculated the Young’s modulus for retina to be in the order of $2 \times 10^4$ Pascals. This value is very much lower than rubber of a similar thickness. The implication of this finding is that the yield strength of the retina is relatively low and traction directed to localised areas of the retina will induce retinal breaks.

The morphology of the retinal break is believed to be determined by the extent and contour of the abnormal interface. There are, however, few reports in the literature citing the histopathology of the supposed abnormal interface. There is, nevertheless, good evidence to show that the ILM consisting of Mueller cell processes and type IV collagen can
remodel following injury or insult, and it is certainly feasible that retinal breaks can occur at this interface.\textsuperscript{(14, 68-70)}

Retinal breaks arising during the course of a PVD are usually referred to as retinal tears and include such descriptions as horseshoe tears, round or oval holes, and U-shaped tears. Retinal dialyses may also develop as a result of a PVD, but typically the posterior hyaloid remains adherent to the posterior margin of the detached retina.\textsuperscript{(71, 72)}

Retinal breaks can occur at a number of locations and sites but have a predilection for the superior retina, with most being anterior to the equator.\textsuperscript{(73)} It has already been noted that the vitreous cortex and retina have stronger attachments along the retinal vessels and this accounts for the frequent clinical association of a retinal tear presenting with a vitreous haemorrhage.\textsuperscript{(74)}

\subsection{2.9 Retinal Breaks without Traction.}

It is important to note that not all retinal breaks occur as a result of traction. Furthermore, retinal breaks associated with free-floating operculum are unlikely to progress to a RRD in the absence of traction on the retina.\textsuperscript{(75, 76)} Conversely, retinal tears with evidence of persistent or recent traction are more likely to progress to RRD.\textsuperscript{(77)}

The majority of RRDs result from pathological PVDs.\textsuperscript{(78)} Retinal detachments occurring in the absence of vitreo-retinal traction are usually secondary to either retinal dialyses or round retinal holes.\textsuperscript{(78)} Retinal dialysis is more commonly found in children or young adults, and there is a male preponderance. Trauma is not usually a feature of idiopathic retinal dialysis and myopia is uncommon, with most being either emmetropic or hyperopic.\textsuperscript{(78-80)}

The overall risk of RRD in eyes with round retinal holes is low, although accounts for up to 20\% of RRD in some series.\textsuperscript{(81, 82)} In this setting the retinal holes can be multiple, typically small, and may be associated with adjacent retinal degenerative change such as lattice or
vascular abnormalities. Round hole detachments appear to have a predilection for young myopic patients and may be more common in certain racial groups. The association of traction and RRD in most cases implies there is a mechanical role in the pathogenesis of retinal detachment, but of course this observation does not prove such a mechanism, nor indeed imply it is the only mechanism. In an attempt to identify those other factors which may collectively, or in part, contribute to the development of a retinal detachment, the interaction of the vitreous and the relationship of the photoreceptors to the RPE has been investigated.

2.10 Retinal Adhesion.

Under normal physiological conditions the outer segments of the photoreceptors and microvilli of the apical surface of the RPE are closely approximated. The apposition of these two layers is maintained by a variety of mechanisms including an adhesive extra-cellular matrix, and active and passive ionic fluxes, together with hydrostatic and osmotic pressures. An intact sensory retina also provides a barrier to the bulk flow of water into the sub-retinal space, as do the tight junctions, or zonula adherens, which are located on the lateral surfaces of the RPE. The relative importance of these mechanisms under physiological and pathological conditions has not been determined, but distinct system failures are believed to occur with conditions such as idiopathic central serous retinopathy, as well as RRDs. The extra-cellular matrix that permeates the potential space between the outer segments of the photoreceptors and the microvilli of the retinal pigment epithelium is believed to play an important role in retinal adhesion. This matrix, usually referred to as the interphotoreceptor matrix (IPM), is comprised of a mix of glycosaminoglycans, glycoproteins and proteoglycans,
as well as a host of smaller proteins such as interphotoreceptor retinoid binding protein (IRBP) and various growth factors.\(^{(29, 89-91)}\)

**Figure 2-8:** Transmission electron microscopy demonstrating the physical relationship of the photoreceptor outer segments with the retinal pigment epithelium. The interphotoreceptor matrix occupies the spaces between the microvilli of the RPE and outer segments of the photoreceptors.

The adhesive nature of the IPM has been elegantly demonstrated by Marmor et al, who showed that any attempt to induce a retinal detachment in freshly prepared human eyes lead to stretching of the IPM,\(^{(49)}\) and elongation of the cone sheaths before dehiscence occurs.\(^{(92)}\)

The integrity of the IPM is highly dependent on such parameters as pH and temperature, as well as the presence of vitreous proteins and active transport systems.\(^{(93)}\) Furthermore, there is a rapid decrease in retinal adhesion in post mortem eyes suggesting oxidative metabolism is required to maintain the binding properties of the macromolecules within the IPM.\(^{(85)}\)
Oxidative metabolism is believed also to play a crucial role in maintaining the sub-retinal space by facilitating the active transport of water across the RPE.\textsuperscript{(94)} Like most other epithelial layers, the RPE has an important role in maintaining active transport systems. In the RPE ionic pumps not only regulate the concentration of intra-cellular ions, but also have a role in maintaining the physiology of the sub-retinal space.\textsuperscript{(86, 95)} In human RPE cells the ionic pumps are located on both the apical and basolateral surfaces. Fluid entry on the apical surface is mediated by sodium and potassium pumps, while a chloride co-transporter system located on the lateral surface governs the transfer of water from the RPE.\textsuperscript{(86, 96)} The regulation of the transport systems can be influenced by a variety of paracrine, autocrine and hormonal signaling molecules, which may not only alter the magnitude of the fluxes, but also the directionality.\textsuperscript{(97, 98)} Failure of the ionic pumps or their up-regulation can secondarily influence the hydration of the IPM and adversely affect retinal adhesion.\textsuperscript{(98-100)}

\textbf{Figure 2-9:} Diagrammatic representation of ionic pumps at the level of the RPE involved in maintaining the integrity of the sub-retinal space.

\textbf{IPRB} = Inter photoreceptor binding proteins
2.11 Pathophysiology of the Sub-retinal Space.

It has been established that in eyes with a detached retina, the source of the sub-retinal fluid is vitreous fluid, and it is proposed therefore that liquefied vitreous can pass through the retinal break and cause a progressive accumulation of sub-retinal fluid.\(^{100}\) The transfer of fluid into the sub-retinal space can be variable and clinical experience has shown that bed rest can reduce or even eliminate the sub-retinal fluid. In these eyes it is believed that residual vitreous gel tamponades the retinal break, permitting secondary resorption of the sub-retinal fluid.\(^{101, 102}\) This observation points to a role of the vitreous gel in maintaining or limiting the extent of a retinal detachment and highlights the possibility of reversing the accumulation of fluid in the sub-retinal space.

In addition to liquid vitreous, sub-retinal fluid has also been shown to contain other proteins and macromolecules.\(^{95, 103, 104}\) The presence of these substances together with ionic salts has raised the possibility that both osmotic and hydrostatic forces may influence the progression and outcome of the detached retina.\(^{104, 105}\)

According to basic physiological principles, the net effect of the hydrostatic pressure acting on the sub-retinal space is determined by the differential in ambient pressure exerted by the vitreous and choroid. Under normal or near-normal physiological conditions the differential is minimal since the sensory retina is relatively resistant to fluid movement and the inner and outer retinal blood barrier prevents fluid movement across the retina and RPE respectively.\(^{105, 106}\)

Conversely, eyes with RRDs have, by definition, breaks in the retina and so a conduit exists for the movement of fluid from the vitreous cavity to the sub-retinal space. In practice, not all eyes with RRD progress to total detachment, suggesting the process is limited because either an up-regulation in fluid transport occurs across the RPE or the alteration in the hydrostatic vectors are not overwhelming.\(^{107}\)
Osmotic pressure is determined by differences in concentrations of solutes across a semi-permeable membrane.\(^{(108)}\) The osmotic pressure influencing the sub-retinal space will depend on the differential in concentration of the solutes in the vitreous and sub-retinal space; and the sub-retinal space and the extra-vascular choroid. Little is known about the concentration of solutes in the sub-retinal space and extra-vascular choroidal compartment. The concentration of proteins and solutes in the vitreous is more clearly understood, but currently there is insufficient data to determine the magnitude of the osmotic fluxes occurring across the retina. Similar gaps occur in our knowledge with respect to the osmotic forces acting across the RPE. However, it has been possible to evaluate the relative contribution of an intact RPE barrier versus a disrupted barrier and also useful information has been gained by injecting fluids of varying osmolarity into the sub-retinal space.\(^{(88, 106)}\) Re-absorption of fluid from the sub-retinal space has been shown to be enhanced by focal laser treatment to the RPE, suggesting that under some circumstances, the osmotic fluxes not only outweigh the contributions made by the active transport systems of the RPE, but that disruption of the RPE facilitates the passage of water to the choroid.\(^{(87)}\)

Negi et al has also shown the transfer of water from the sub-retinal space is inversely proportional to the osmolarity of the sub-retinal space.\(^{(104)}\) The greater the osmolarity, the slower the transfer. It follows therefore that in at least some eyes with detached retinæ, the contribution of osmotic fluxes to absorption of sub-retinal fluid may be less if the sub-retinal fluid contains substantial amounts of protein.\(^{(104)}\)

Under normal physiological conditions the net effect of both hydrostatic and osmotic pressure is believed to favour a fluid shift from the sub-retinal space to the choroid.\(^{(86, 103, 104)}\) Conversely, in the presence of a retinal tear, and persistent traction on the break, fluid from the vitreous cavity will likely pass into the sub-retinal space and unless limited by vitreous
tamponade or an equal and opposite flux across the RPE, culminate in a retinal detachment.\textsuperscript{86, 95}

2.12 Conclusion.

The current thesis supports the view that a RRD may develop following a retinal tear and that in most eyes the tear occurs as a consequence of an abnormal adhesion between the vitreous cortex and ILM of the retina. Persistent traction on the retinal tear may facilitate movement of fluid from the vitreous to the sub-retinal space which, if sufficient to overwhelm the maintenance of the sub-retinal space, will lead to retinal detachment.
2.13 References.


Chapter 3: The Epidemiology and Natural History of Lesions Associated with Rhegmatogenous Retinal Detachment.

Epidemiological research into the development of RRD has highlighted the linkage with age and sex for groups at risk. Personal risk factors include the presence of high myopia, increasing age and a history of intra-ocular surgery. [1-3] The significance of these and other risk factors will be re-examined in light of recent studies into the natural history of rhegmatogenous retinal detachment and the implications for prophylactic treatment will be evaluated.

3.1 Introduction.

Most RRD are idiopathic although a small percentage may be associated with trauma or with intra-ocular surgery.[2, 4, 5] Eyes most at risk from RRD are those that are myopic, especially greater than 6.0D.[6, 7] There is in most studies a small predilection for the male sex and the prevalence of RRD increases with age.[7]

RRD following cataract surgery is well recognised, with the risk being greater in eyes left aphakic or who have undergone intra-capsular surgery. Cataracts removed using extra-capsular or phaco-emulsification techniques have a lower risk.[8]

Blunt or penetrating ocular trauma is also associated with an increased risk of RRD as are many types of intra-ocular surgery, such as macular hole surgery, pneumatic retinopexy and glaucoma drainage surgeries.[9-11] Interestingly, the Endophthalmitis Vitrectomy Study found RRD occurred in nearly 10% of patients who developed endophthalmitis following cataract surgery.[12]
3.2 Posterior Vitreous Detachment.

The development of an acute posterior vitreous detachment is a risk factor for retinal tear formation and subsequent development of a RRD. According to Byer, 95% of RRD arise as the result of a PVD. The incidence of PVD increases with age as does the risk of RRD. High myopes also have an increased risk of RRD and in these eyes a PVD occurs approximately 10 years earlier than age-matched emmetropic eyes.

The most frequent symptoms associated with PVD include flashes and floaters. Flashes are thought to result from traction on the peripheral retina, are momentary entoptic phenomena usually seen in the temporal periphery as silvery lights. Floaters, on the other hand, can range from a discrete solitary floater, to multiple small mobile dots, to murky, transparent obscuration involving the central visual field. The presence of multiple dots implies the presence of blood in the vitreous cavity and increases the likelihood of a retinal tear.

Acute symptomatic PVD is associated with a retinal tear in approximately 15% of eyes. Patients with PVD and blood in the vitreous cavity have approximately 70% chance of a retinal tear, while those patients with tobacco dust likely have a greater risk.

Figure 3-1: Relationship of age and posterior vitreous detachment. From Akiba, 1993.
3.3  Retinal Breaks.

The precursor to most RRD is the development of a retinal tear usually induced by a PVD.\(^{(13)}\)
A retinal tear is defined as a full-thickness retinal defect, and typically results from dynamic vitreo-retinal traction.\(^{(22)}\) Less commonly, RRD can develop as a consequence of retinal holes which can be precipitated by traction but more often result from atrophy and so may occur in the absence of a PVD.\(^{(23)}\) Atrophic holes can originate in or adjacent to other peripheral retinal degenerations (PRD) such as lattice degeneration, retinoschisis and snailtrack lesions.\(^{(24)}\)
There may be both a racial and age related dichotomy for patients presenting with a retinal detachment with respect to retinal break.\(^{(25, 26)}\)

**Table 3-1: Types of retinal breaks.**

<table>
<thead>
<tr>
<th>Retinal Tears: Result from vitreo-retinal traction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retinal Holes: Usually result from atrophy</td>
</tr>
</tbody>
</table>

Retinal breaks may be associated with symptoms although retinal holes are frequently asymptomatic.\(^{(27)}\) Those symptoms most commonly reported in patients with a retinal break are not specific and include flashes, floaters, as well as other subjective alterations in vision.\(^{(28, 29)}\)

A large number of clinical and autopsy studies have demonstrated that retinal breaks can exist in otherwise seemingly normal eyes.\(^{(30-32)}\) Foos reported on a series of eyes and elaborated on the histology of breaks including both retinal tears and holes.\(^{(33)}\) Okun in a similar study of autopsy eyes found the incidence of retinal breaks in eyes over the age of 40 years was 7%.\(^{(31)}\)
This finding is consistent with Byer who examined 1700 patients without known retinal
disease and found that 98 (5.8%) had a retinal break.\(^{(23)}\) In all, a total of 156 breaks were found in 111 eyes. Eighty five retinal breaks were directly associated with areas of lattice degeneration although 78 (50%) of the eyes had breaks at points distal to the areas of lattice. Most patients had retinal holes without operculum but of those with horse shoe tears, 94% were a half disc diameter or smaller.

**Figure 3-2: Types of retinal breaks in eyes without RRD.**

<table>
<thead>
<tr>
<th>Type of Break</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horseshoe Tear</td>
<td>16</td>
<td>10%</td>
</tr>
<tr>
<td>Hole with free Operculum</td>
<td>21</td>
<td>13%</td>
</tr>
<tr>
<td>Hole without Operculum</td>
<td>120</td>
<td>76%</td>
</tr>
</tbody>
</table>

*From Byer (1967)*

Subsequently Byer reported on a cohort of 196 patients with asymptomatic retinal breaks that had been followed for at least 10 years.\(^{(34)}\) Over this interval no patient developed a clinical retinal detachment, although in some eyes new retinal breaks occurred. Furthermore, of those eyes that developed a PVD no adverse incident occurred. Whilst Byer excluded patients with RRD in the fellow eye he did include eyes with a variety of retinal breaks including eyes with retinal tears with attached flaps, implying continued traction. Approximately half the tears were in the superior retina and again approximately half the eyes were myopic.\(^{(34)}\) From this study Byer concluded that asymptomatic retinal breaks rarely progress to clinical RRD. Other authors have agreed that asymptomatic retinal breaks rarely progress to RRD with the possible exceptions of inferior retinal dialysis, those with fellow eye involvement, and fellow eyes with atrophic holes in lattice degeneration.\(^{(35-38)}\)
The natural history of patients with symptomatic retinal breaks is less well documented. In 1943 Granstrom described a patient with a retinal hole who he followed for 15 months before the retina detached.\(^{39}\) Colyear and Pischel have also reported a series of 15 eyes with symptomatic retinal tears, 4 (26.6%) of whom progressed to RRD.\(^{40}\) Byer has calculated from his study of patients presenting with acute PVD that the risk of developing a RRD in the presence of acute tractional retinal tears is approximately 50%.\(^{41}\)

### 3.4 Peripheral Retinal Degenerations.

The presence of at least some types of peripheral retinal degeneration (PRD) in eyes with RRD suggests a causal relationship exists and various approaches have attempted to define that risk.\(^{20, 42, 43}\) Furthermore, some eyes with PRD contain retinal breaks and the linkage of PRD, retinal breaks and RRD has provoked parallel enquiry.\(^{38, 44, 45}\)

A wide variety of PRD have been described, but only a limited number are thought to be important in the development of RRD.\(^{46}\) The lesions most commonly implicated in the pathogenesis of RRD include lattice degeneration, peripheral retinoschisis and retinal tufts.

<table>
<thead>
<tr>
<th>Peripheral retinal degenerations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retinal Tufts</td>
</tr>
<tr>
<td>Retinoschisis</td>
</tr>
<tr>
<td>Lattice Degeneration</td>
</tr>
<tr>
<td>Snail Track Degeneration</td>
</tr>
<tr>
<td>Peripheral Cystoid Degeneration</td>
</tr>
</tbody>
</table>
3.5 **Lattice Degeneration.**

Lattice degeneration was first described by Gonin in 1933.\(^{(47)}\) He called these lesions “Schneckenspuuen” meaning snail tracks after the white arborising tracks found in the base of the lesion. Schepens recognised that the snail tracks or pallisading within the lesions represented sclerotic vessels. Schepens also described other clinical features associated with this lesion and coined the now popular term lattice degeneration.\(^{(32)}\)

It is accepted that the clinical features of lattice degeneration can be variable, but typically the lesions are discrete, located anterior to the equator, and are oval or linear.\(^{(33)}\) Most often they are arranged circumferentially although infrequently can have a radial orientation particularly if they are posterior to the equator and have a perivascular distribution.\(^{(46)}\) The lesions may be multiple, and approximately half the patients have bilateral involvement.\(^{(48)}\) Lattice degeneration can be pigmented and may be associated with round holes. The holes may be within, or adjacent to, the lesion.\(^{(35,48)}\)

In most cases lattice degeneration occurs sporadically but familial cases have been reported.\(^{(24,49)}\) It is not certain whether the familial cases are a variant of lattice degeneration or a separate entity. Snail track degeneration is sometimes used when describing familial cases which, like sporadic cases, are more commonly associated with myopia.\(^{(49)}\)
In this example there are multiple atrophic holes in the lesion.

The histology of lattice degeneration reveals the retina in the lesion to be thinner particularly at the level of the inner retina. There is, typically, condensation and vitreo-retinal adhesion at the margins of the lesions with sclerosis of the retinal vessels corresponding to the lattice appearance seen clinically in about 10% of such cases. Atrophic retinal holes are found within lattice degeneration in about 20% of cases.

Lattice degeneration occurs in approximately 8% of the adult population and co-exists in 30% of patients presenting with RRD. The association of lattice degeneration and RRD has been further highlighted by Morse and Scheie who reported in a series of 223 eyes with primary RRD, 31 eyes or 13.9% resulted from atrophic holes occurring within areas of lattice degeneration. Conversely, Byer reported on 276 consecutive, untreated patients who were found to have lattice degeneration on routine ophthalmoscopy. Three eyes (1.08%) developed a clinical RRD during the follow-up period which ranged from 1 to 25 years. Atrophic holes were found in 150 eyes (35%) and 4 eyes had asymptomatic retinal tears.
Prophylactic treatment was not applied to either group. Five eyes developed symptomatic retinal tears while under review and all were treated. In the 3 eyes that developed progressive RRD, 2 extended from round holes in the areas of lattice while the other patient developed a retinal tear adjacent to an area of lattice.

3.6 Degenerative Retinoschisis.

Retinoschisis is a generic term used to define a splitting of the neural retina. Typically, retinoschises are classified according to presumed aetiology or appearance. A common classification system describes a congenital form, as well as tractional and degenerative types.\(^{(53)}\) The congenital form, usually X-linked, is related to abnormalities in protein synthesis and typically involves the macula and approximately 2/3 the peripheral retina. It is only rarely associated with RRD.\(^{(54,55)}\)

Tractional retinoschisis is associated with other tractional retinopathies such as in diabetic tractional retinal detachments and other secondary forms of retinal detachments.\(^{(53)}\) Degenerative retinoschisis may account for 1% to 12% of RRD, although the figure of 3% is commonly cited.\(^{(55-58)}\) Degenerative retinoschises are a common retinal finding and are found in approximately 7% of asymptomatic, apparently normal individuals.\(^{(59)}\) They are typically bilateral, although involvement is often asymmetrical. Degenerative retinoschises have a predilection for the infero-temporal quadrant and are most commonly seen in hyperopes.\(^{(60)}\) Indeed, 70% of patients with degenerative schisis are hyperopes.\(^{(61)}\)

Schisis usually extend from the ora serrata and in about ¾ of cases have posterior borders extending to the post-equatorial retina.\(^{(59)}\) The splitting occurs at the level of the outer plexiform layer, the same level as the cystoid spaces which occur in peripheral cystoid degeneration. Degenerative schises are often associated with peripheral cystoid degeneration, although the latter most commonly exists as an isolated entity. Because of the histopathologic
similarities between schisis and cystoid there is a view that retinoschisis develops from peripheral cystoid degeneration.\(^{(55, 61)}\)

Retinal breaks may complicate retinoschisis and can occur in either the outer or inner leaf of the schisis, the former being more common.\(^{(59, 62)}\) The outer leaf breaks may be large and simulate a retinal dialysis. They are more commonly seen toward the posterior margin of the schisis.\(^{(59)}\) Breaks in the inner leaf are typically smaller and because of the almost transparent and extremely thin layer that comprises the inner leaf, often difficult to see.\(^{(63)}\) Development of both inner and outer leaf breaks permits fluid to accumulate in the sub-retinal space and can lead to a RRD.\(^{(60)}\)

Clinically, retinoschisis and RRD may be difficult to distinguish. The absence of pigment in the vitreous and an attached hyaloid points more to a schisis than detachment but other useful tools to differentiate include visual fields and more recently OCT.\(^{(58, 64)}\)

Degenerative retinoschises are believed to be benign in most eyes. However, some retinoschisis extend posteriorly and can involve the macula with resultant loss of central vision. In a large natural history study, Byer followed 123 non-selected patients with a total of 218 eyes for a mean of nearly 10 years. Posterior extension of the schisis cavity occurred in 3.2% of the eyes while circumferential extension occurred in 6.4%. All the patients remained asymptomatic and the macula was not threatened in any eye. Similarly, Brockhurst reported on 23,000 consecutive patients with varying peripheral pathologies and found only 3 cases where the macula was involved by a retinoschisis.\(^{(65)}\)

In eyes where there is documented progression of the schisis and the macula becomes threatened, various treatment modalities have been recommended including cryotherapy, barrier laser photocoagulation and scleral buckling surgery.\(^{(55, 65, 66)}\)

Similarly, development of a RRD in an eye with schisis is uncommon.\(^{(55, 67)}\) However, it does appear likely from recent reports using OCT that the presence of fluid in the sub-retinal
space is more common than previously believed and that localised forms of retinal
detachment co-exist with degenerative retinoschisis. (68)

3.7 Cystic Retinal Tufts.

Tufting of the peripheral retina is a relatively common finding. Two forms exist - cystic and
non-cystic. The latter tend to be smaller than the cystic variety, around 0.1mm, appear solid
and tend to be located in the nasal periphery. (69) Avulsion of the non-cystic tuft results in
small retinal fragments becoming entrapped in the vitreous near the vitreous base. Avulsion
does not lead to a full thickness retinal break and hence non-cystic retinal tufts are benign. (69)
Cystic retinal tufts are also small, less than 1.0mm, although larger than the non-cystic
variety. They appear cystic and represent cystic areas of gliotic degeneration that are typically
located at the vitreous base or anterior to the retinal equator. (33, 42) They can be found in any
quadrant of the retina and may be single or in clusters and are frequently unilateral. These
lesions are generally stable over time although they may, because of continued vitreous
traction, undergo slight changes in shape. Avulsion of cystic retinal tufts can lead to a full
thickness retinal break which usually has the appearance of a round hole. (69) Round holes can
occur in the presence of an attached vitreous but are more commonly found following a
PVD. (42) Cystic retinal tufts may account for as many as 10% of RRD, (44, 70, 71) but the risk of
a cystic retinal tuft progressing to a RRD is calculated at less than 1.0%. (70)

3.8 Other Risk Factors Associated with RRD.

There are a number of reports in the literature detailing the risk of RRD in the fellow eye for a
patient who has already presented with a RRD. (45, 72-74) The reported incidence ranges from 8
to 30% with a life time risk of 10% generally quoted. (75-77) The wide variation in incidence
probably reflects differences in ability to access treatment, mortality, as well as the inclusion
and exclusion criteria adopted in the various studies. However, there is a consensus that the fellow eye in elderly, myopic individuals, with attached hyaloid and lattice degeneration are more at risk.  

Myopia and intra-ocular surgery are risk factors for RRD and, while a variety of mechanisms may precipitate the detachment, most are believed to follow vitreous traction and/or PVD. These factors will be elaborated on separately in a subsequent chapter.

3.9 Prophylaxis of RRD.

The exact relationship of retinal breaks and other peripheral retinal degenerations to RRD remains unclear and debate persists as to the merits of prophylactic therapy. Gonin was of the belief that “every retinal tear has its detachment and every detachment has its tear”. However, as has been noted, the prevalence of retinal breaks greatly exceeds the number of RRD occurring in the community. Similarly, although some PRD such as lattice degeneration, cystic retinal tufts and peripheral retinoschisis are associated with RRD, not all such eyes with these PRD progress to a clinical detachment. The corollary of this observation is what eyes if any justify prophylactic treatment and whether such treatment is beneficial. Integral in this assessment is an appreciation of the risks and complications of treatment as well the effectiveness of the treatment.

In the case of RRD secondary to retinoschisis or cystic retinal tufts there is no evidence to suggest prophylactic treatment is effective.

There is, however, broad agreement for Byer’s view that a dilated retinal examination for patients presenting with symptomatic PVD is required and this remains the premier line of defense against retinal detachment. The discovery of retinal breaks in this setting requires an assessment as to whether the break has resulted from the PVD or is a pre-existing lesion. A round atrophic hole adjacent to an area of lattice is likely to represent an incidental finding
whereas the presence of a retinal tear usually indicates vitreo-retinal traction. That traction is likely to persist if there is an anterior flap associated, but be absent if the tear has a free operculum. The two natural history studies documenting symptomatic retinal tears, together with the effectiveness of prophylactic treatment, lead most retinal specialists to advocate treatment.\(^{(39,40)}\) The weight of evidence suggests there is no need for treatment for asymptomatic retinal breaks, although if there is a history of a RRD in the fellow eye then some would argue treatment is appropriate.\(^{(72, 81, 84)}\)

The large, prospective study documenting the natural history of lattice degeneration published by Byer demonstrated that the risk of RRD was low and that the presence of atrophic holes was not an indication for prophylaxis. \(^{(52)}\) Byer’s study excluded patients with a history of RRD and did not evaluate fellow eye involvement, refractive status or age. It is conceivable that these risk factors may have influenced the rate of RRD. Folk has attempted to address the usefulness of prophylaxis to the fellow eye in a group of patients perceived more at risk; those with high myopia and lattice degeneration. All patients had undergone retinal re-attachment surgery in their presenting eye. In Folk’s series, involving 315 eyes, prophylactic treatment reduced the risk of RRD from 9 of 151 eyes (5.1%) to 3 of 164 eyes (1.8%). This difference was not found to be statistically significant. \(^{(45)}\) A similar retrospective study on 305 eyes, seemingly closely matched with that reported by Folk, did show a low rate of RRD in the fellow eye suggesting prophylactic treatment was useful. \(^{(81)}\)

Burton has also evaluated the effectiveness of treatment in a similar group of patients, stratified according to age and refraction.\(^{(25)}\) Using data from 172 residents of the State of Iowa who developed a retinal detachment, he calculated the lifetime risk of a retinal detachment in the presence of lattice degeneration progressively increased with increasing myopia. The lifetime risk for an emmetrope with lattice degeneration was 1.7%, increasing to 35.9% for myopes with greater than -5D.
Burton also determined, assuming prophylactic treatment was effective in preventing RRD, one would need to treat 1,000 emmetropic eyes with lattice degeneration in the 30-39 age group to prevent a single RRD over a 10 year period. No calculation was proffered for the low to moderate individuals with lattice degeneration but Burton calculated that within the United States population, there would be about 1,150 individuals per million aged between 10 and 39 years with myopia exceeding -5.0D. In this group where the risk of RRD is greatest, 4 RRD would be expected annually or 40 detachments in a 10 year period. For this group of patients Burton advised enhanced vigilance but stopped short of recommending prophylaxis. (25)

Prophylactic treatment of lattice degeneration for patients undergoing cataract surgery has also been investigated, but again the conclusions are limited. (85) Indeed the limitation of applying prophylactic treatment to areas of lattice and any associated round retinal holes is that not all RRD develop from these areas. (73, 86) Indeed Byer has noted that the majority of retinal tears and resulting RRD develop in areas of seemingly normal areas of retina. (51) Some authors have advocated prophylactic treatment should be applied for 360° in high risk eyes but these reports tend to be more anecdotal. (51, 87)

Prophylaxis has also been advocated for patients with RRD secondary to giant retinal tear (GRT). (88) Patients presenting with non-traumatic GRT have a 20% risk of developing a RRD in their fellow eye while the risk approaches 70% for patients with Stickler syndrome. (89, 90) Given that the aetiology of non-traumatic GRT is thought to be secondary to vitreous base shrinkage, various treatments have been advocated including 360° encirclement, cryotherapy and laser photocoagulation. (87, 88, 91) None of the reported studies totally eliminated the risk to the fellow eye although cryotherapy to the posterior border of the vitreous base resulted in a 6% RRD rate. (92) The authors in this latter study noted it would require a sample size of 645 patients randomised to either treatment or observation to validate the usage of cryotherapy in eyes at risk.
Snead et al also reported on the efficacy of cryotherapy in preventing RRD secondary to GRT in the fellow eye of patients with Stickler syndrome. Applying 360° contiguous retinopexy to the fellow eye limited the retinal detachment rate to 7%. (90)

In the absence of prospective, randomised studies evaluating the efficacy of prophylactic treatment for RRD, the current practice guidelines remain wedded to that combination of natural history studies, retrospective reviews, fellow eye studies and expert opinion. (34)

An alternative approach in absence of hard data has been to analyse the contemporary literature with electronic search engines and evaluate the strength of evidence to support any such recommendation. This evidence-based approach has been utilised for both symptomatic and asymptomatic retinal breaks, as well as lattice degeneration and evaluated according to "importance to care process" and "strength of evidence", (80) both of these parameters being further divided according to levels of importance.

Table 3-3: Importance to the care process.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Level A, defined as most important</td>
</tr>
<tr>
<td>B</td>
<td>Level B, defined as moderately important</td>
</tr>
<tr>
<td>C</td>
<td>Level C, defined as relevant but not critical</td>
</tr>
</tbody>
</table>

Table 3-4: Strength of evidence.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Level I, defined as data that provided strong evidence</td>
</tr>
<tr>
<td>II</td>
<td>Level II, defined as data that provided substantial evidence</td>
</tr>
<tr>
<td>III</td>
<td>Level III, consensus of opinion in absence of level 1 and level 2</td>
</tr>
</tbody>
</table>

On this basis, a rating of A:II would support the recommendation to apply prophylactic treatment which had a high importance to clinical care (A) supported by meaningful published
evidence (II), but not with a randomised controlled study or retrospective study with a statistical outcome.\(^{(93)}\)

Using these criteria, all 25 recommendations identified by this review for treatment were categorised as Level A. However, only symptomatic retinal tears rated Level I. This recommendation was based primarily on retrospective studies demonstrating that untreated symptomatic retinal tears frequently progressed to clinical RRD and treatment was usually effective.

A Level II rating was given to 8 lesions where there was thought to be substantial evidence suggesting treatment was not desirable, or rarely required treatment, or that treatment was sometimes justifiable.

A large number of lesions and situations were categorised as level III where there was no substantive evidence regarding treatment but that the panel provided a consensus opinion or guidance. These recommendations are detailed in Table 3-5.
Table 3-5: Guidelines for treatment of peripheral retinal lesions.

<table>
<thead>
<tr>
<th>Strength of Evidence</th>
<th>Recommendation</th>
<th>Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Strong</td>
<td>Always treat</td>
<td>Symptomatic tear</td>
</tr>
<tr>
<td>II: Substantial</td>
<td>No treatment</td>
<td>Asymptomatic operculated tear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic lattice in phakic eyes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic atrophic holes in myopes</td>
</tr>
<tr>
<td></td>
<td>Rarely treat</td>
<td>Asymptomatic atrophic holes in phakic eyes</td>
</tr>
<tr>
<td></td>
<td>Sometimes treat</td>
<td>Lattice in fellow eyes</td>
</tr>
<tr>
<td>III: Consensus</td>
<td>Rarely treat</td>
<td>Asymptomatic operculated tears in myopes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic operculated tears in fellow eyes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic operculated tears in aphakics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic atrophic holes in myopes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic atrophic holes in fellow eyes</td>
</tr>
<tr>
<td></td>
<td>Sometimes treat</td>
<td>Asymptomatic tears in phakic eyes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic tears in myopes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic tears in fellow eyes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asymptomatic tears in aphakics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Symptomatic operculated tears</td>
</tr>
<tr>
<td></td>
<td>Almost always treat</td>
<td>Asymptomatic dialysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Symptomatic dialysis</td>
</tr>
</tbody>
</table>

Modified from Wilkinson, CP. (2000)

The inherent advantages in basing medical treatment on best practice or an evidence-based approach facilitates a more rational approach to treatment and identifies areas where further research is required and how that might be achieved. Furthermore, evidence-based medicine provides a framework for assessing cost utility analysis and overall better treatment for our patients.
3.10 References.


47. Gonin J. The evolution of ideas concerning retinal detachment within the last five years. Br J Ophthalmol 1933;17:726-729.


Chapter 4: History of Retinal Surgery in New Zealand.

The history of retinal surgery in New Zealand is relatively short but covers a period of transition from caustic cautery to laser retinopexy; from scleral shortening to 25 gauge vitrectomy. The practitioners of this craft include some of the notable figures in medicine in New Zealand, and in their own way each contributed to the welfare of those patients with surgical retinal disease.

4.1 Gonin Period.

The modern history of retinal re-attachment surgery developed on Continental Europe in the early 1920s when Jules Gonin devised a method for inducing retinopexy. Gonin recognised that the key to successful surgery entailed sealing the retinal breaks. However while the "Gonin method", as the technique was called, was readily accepted on continental Europe the technique did not become popular in the English speaking world until sanctioned by Lister in 1929. (1)

Gonin subsequently described his approach to retinal detachments and collated his experience, complete with beautiful drawings in his treatise, Le Decollement de la Retine. (2) The retinal drawings are perhaps even more impressive when one considers Gonin used a direct ophthalmoscope to visualise the ocular fundus.

4.2 Scleral Shortening Procedures and Buckling.

While Gonin reported excellent results with his techniques, there were technical difficulties associated with inducing retinopexy by cautery especially those eyes with bullous
detachments. Furthermore the eyes with chronic retinal detachments, less mobile retinae and viscous sub-retinal fluid were more difficult to re-attach.

To address some of these issues a variety of scleral shortening techniques were devised which facilitated the approximation of the retina to the choroid.\textsuperscript{(3, 4)}

**Figure 4-1:** Full thickness lamellar dissection was used for chronic and bullous retinal detachments.
In this figure caustic cautery is being directly applied to the choroid with an applicator.

Shapland, who subsequently had a special influence on retinal surgery in New Zealand, popularised a lamellar scleral resection technique for this group of patients and thereby avoided direct injury to the choroid more commonly seen with full thickness scleral resections.\textsuperscript{(5)} In spite of these modifications, the realisation that scleral shortening techniques could only produce a diffuse indent, lead other investigators to explore alternative methods of inducing an indentation at the site of the retinal break.\textsuperscript{(6)} Custodis is credited with introducing the concept of scleral buckling and highlighted the need for the buckle to be positioned so that
the retinal break lies against the choroid on the summit of the indentation. The original indent material used by Custodis was polyviol, a red-rubbery substance made of polyviol alcohol, gum Arabic and Congo red. Polyviol had excellent elastic properties but tended to produce excessive inflammatory responses in some individuals. Polyviol was only briefly used in New Zealand and silicone sponge became the material of choice. Initially silicone sponge was available from the ophthalmic suppliers Labtician, in foot-long lengths but changing realities soon limited the supply to lengths suitable only for individual surgeries. Subsequent developments in buckling materials were adopted by New Zealand practitioners and the solid silicone tyres and straps became more common as a wider range of techniques were introduced for re-attaching the retina.

4.3 Methods of Retinopexy.

Gonin treated retinal breaks with a cautery probe obtained at a toy store, originally devised for burning designs in wooden toys. This method of retinopexy was subsequently superceded by alternative approaches including diathermy and chemical cauterisation.

Professor John Parr was a registrar of Shapland when the latter was a consultant at Moorfields Eye Hospital. When Professor Parr returned to New Zealand in the early 1950s, he adopted many of Shapland's techniques and, having experience with caustic potash as a method of inducing retinopexy, was able to use this agent until a diathermy unit was purchased by Dunedin Hospital. (Parr J, personal communication)

Chemical cauterisation had the distinct advantage over the Gonin cautery method by enabling eyes with more than one retinal break to be treated and facilitating a more widespread area of reaction to be produced at a single operation.
The typical complications experienced with cautery puncture, vitreous haemorrhage, development of secondary holes, and uveitis were less frequent with chemical cauterisation.

The technique utilised by Parr involved performing multiple trephines of the sclera (1.5mm) and applying solid caustic potash to the choroid and after about one second neutralising the cauterising agent with 1% acetic acid.

Diathermy was also shown to a useful method of inducing retinopexy since the passage of high frequency current through a tissue can cause a thermal reaction. Ophthalmic applications of diathermy require a frequency of 400 KHz to 10MHz with currents approximating 500 mA. (Household electrical supply employs frequencies of 50 Hz and 100 mA, contact at these settings can cause electrocution or ventricular fibrillation). Coagulation will result if the tissue is exposed to interrupted pulses of current (50-100 per second) whereas cutting will predominate if there is a continuous sinusoidal wave-form.

Both uni-polar and bi-polar diathermy modalities had ophthalmic applications. The former requires the placement of a large electrical plate being applied to a distant part of the body while the active electrode is applied to the tissue to be coagulated or cut. The current of the diathermy unit is varied according to the degree of response. Bi-polar diathermy utilises two active electrodes placed in close proximity and the passage of current between the electrodes determines the therapeutic effect.
Figure 4-2a: The diathermy unit first used in the Eye Department at Dunedin Hospital was the 700B Keeler Major Electro-Surgical Unit.

Figure 4-2b: A variety of diathermy tips were used in retinal attachment surgery including those with pointed ends which enabled the electrode to penetrate the scleral lamellar so the current could directly be applied to the choroid. Tips with flatter terminals were typically used for transcleral applications.

The first commercially available diathermy machine for ophthalmic use in New Zealand was the 700B Keeler Major Electro-Surgical Unit produced by Keeler and was of a uni-polar type.
(Keeler R, personal communication) The electrodes available with this unit enabled both trans-scleral and penetrating diathermy to be performed. The former was easier to perform but suffered from the difficulties that sclera was a poor conductor of heat, produced a variable reaction on the choroid and tended to preclude further surgeries being performed because of irreversible damage to the sclera. Penetrating diathermy technique required a scleral flap to be created enabling a pointed electrode to be positioned close to the choroid where it could deliver a more measured effect. While a variety of penetrating diathermy terminal configurations were devised attempting to improve the delivery system, the underlying problem of determining the threshold for retinopexy continued. These and other problems lead to a rise in the popularity of cryotherapy as the preferred method of retinopexy.

In New Zealand in the early 1960s cryotherapy involved pouring liquid nitrogen into a funnel joined to a metallic tube. From there the liquid was allowed to spill onto the sclera. The ice ball created was then thawed with the application of normal saline. Liquid nitrogen was freely available from industrial suppliers during this period but the inability to store the liquid in the hospital environment was a persisting difficulty. Pittar in Auckland accessed his supply from Industrial Gases Ltd for seven and six pence a pint. Subsequently the advent of the Amoils “Cryo Pencil Unit” in the mid 60s revolutionised the use of cryotherapy in ophthalmology. Amoils designed a device that utilised the Joules Thompson principle. This observation had been made by Sir William Thompson, better known as Lord Kelvin, who noted a rapid expansion of a compressed gas when passed through a small orifice produced a large drop in temperature. Amoils was successfully able to produce a fine enough probe which allowed an ice ball to form on the tip and so provided a method to facilitate the cryo-extraction of a cataractous lens. Probes soon became available for retinal surgery and cryotherapy became the method of choice for retinopexy.
Cryo Pencil Units were available in most ophthalmic departments in New Zealand by the end of the 1960s.

Figure 4-3: The Amoils Cryo pencil unit was widely used in New Zealand in the late 1960s for inducing retinopexy by cryotherapy.

In 1969 Meyer-Schwickerath attended a conjoint meeting of the Australian and New Zealand ophthalmic societies and presented a paper outlining the use of the xenon photocoagulator in sealing retinal holes.\(^{15}\) This prompted the Dunedin eye department to purchase a photocoagulator and at the Ophthalmological Society of New Zealand meeting in 1971, Mr Reynolds reported on its efficacy.\(^{16}\) Although the photocoagulator could be used in the treatment of flat retinal breaks, the main indication was in medical retinal practice particularly for retinal vascular diseases.\(^{17,18}\) Certainly in New Zealand, the Zeiss photocoagulator was only occasionally used for surgical retinal pathology.
4.4 The Surgeries.

Retinal re-attachment surgery had been performed in New Zealand prior to the return of Professor Parr to this country but the numbers were small and functional success was variable.\(^{(19, 20)}\)

Simple methods of treatment include bed rest and positioning and surgical intervention reserved for often tragic cases. The conservative approach is illustrated by Coverdale’s management to retinal detachment during the Second World War. He encountered 6 servicemen with retinal detachments during secondment with the Second New Zealand Expeditionary Forces during the Middle East Campaign. Coverdale, based at the New Zealand camp at Helvin 25 km south of Cairo, repatriated these servicemen back to New Zealand rather than refer them to the British Forces Hospital at Cairo for retinal surgery.\(^{(20)}\)

In New Zealand in the 1950s, most retinal surgeries were performed under general anaesthesia and the list of relative contra-indications considered important, together with the difficulties associated with retinal surgery tended to restrict the number of surgeries.\(^{(19, 21)}\) In spite of obvious difficulties, retinal surgery was regularly being performed in most metropolitan centres in New Zealand in the mid to late 1950s.

In Christchurch Dr W Burns was considered as having special expertise. He was elected to the Ophthalmic Society of the United Kingdom in 1948 and was a foundation member of the Ophthalmic Society of New Zealand. Dr Burns was an Honorary Consultant at Christchurch Hospital and had an extensive private practice. He contributed to the first study subsequently published in 1968 by Suckling and Hay that determined the incidence of retinal detachment in the Christchurch region of New Zealand. Their retrospective review was carried out over a 6 year period between 1960 and 1966. The population of the catchment area was 360,000 and 100 surgeries were carried out. The reported incidence was 1 per 20,000 per year.\(^{(21)}\)
This equates to 5 per 100,000 per year which is approximately half the number reported in the Northern NZ Retinal Detachment Study some 35 years later. The paper from the Christchurch surgeons also attempted to define the risk to the fellow eye. Patients who had suffered ocular trauma or who had a familial history of retinal detachment were excluded from the analysis and no patient received prophylactic treatment to the fellow eye. The lifetime risk for the fellow eye was determined to approximate 8%. While this figure is lower than what is generally reported today, it does provide a basis for comparison.

4.5 The Training.

Up until the mid 1970s speciality training for Ophthalmology was limited in New Zealand. Most wishing to pursue a full time career in ophthalmology therefore travelled abroad, mostly to the United Kingdom and undertook training in the London hospitals or at other major centres such as Manchester or Edinburgh. The subsequent influence on retinal practice in New Zealand tended to therefore emanate from these quarters. Thus while Schepens designed a self illuminating binocular indirect ophthalmoscope in 1945 it was the Fison Indirect Ophthalmoscope that found favour in New Zealand. Hylton Le Grice who worked with Fison was instrumental in introducing indirect ophthalmoscopy when he returned to New Zealand in 1967. Fison subsequently visited New Zealand in 1967 as a guest of the OSNZ and toured the country providing practical advice.

The indirect ophthalmoscope utilised by Weve and others was never popular in New Zealand and indeed there was only guarded enthusiasm in the United Kingdom for the Fison Indirect Ophthalmoscope. The feeling may be summed up at the time by Trevor- Roper, who in 1960 commented that...." If the binocular indirect ophthalmoscope is indeed the answer, as the select few surgeons who use it aver, the plain fact is that 99 in a 100 of us will never have the time or facilities to master it’s technique,...."
Figure 4-4: The Fison Indirect Ophthalmoscope was popularised in New Zealand by such proponents as Hylton Le Grice and Bill Taylor.

On-going education in surgical retina practice in New Zealand in the mid and late C20th was maintained by visits to New Zealand from overseas retinal specialists as well as often lengthy excursions by New Zealand practitioners to overseas centres. Many of these exchanges were recorded in the Transactions of the OSNZ. The writing style of the Transactions enabled both descriptive and scientific content to be included. As a result interesting references to personalities, operating practices and relationships are described in a fashion not seen today.
4.6 Sub-specialisation.

The era of sub-specialisation had its beginnings in New Zealand in 1969 when Harold Coop was appointed as the first retinal specialist at Auckland Hospital. Dr Coop, like many of his contemporaries, was trained at Moorfields working with such notable surgeons as Rolf Blach and Lorimer Fison. His knowledge and skill both in New Zealand and the Pacific Islands ensured an extensive retinal practice which he continued until the 1990s. Coop was a master of conventional surgery and retained this focus throughout his professional life. He introduced to New Zealand that generation of explants that followed the Custodis polyviol implants including the silicone sponges and solid silicone explants. Coop was the first in New Zealand to inject silicone oil to eyes with retinal detachments. This technique popularised by Blach involved injecting silicone oil into the vitreous cavity, in a non-vitrectomised eye, as sub-retinal fluid was drained through a sclerotomy.\(^{26}\)

In 1971 William (Bill) Taylor returned to New Zealand and quickly developed a reputation for managing a prodigious retinal work load. Taylor, also Moorfields trained, was a meticulous surgeon and keen observer. Together with Peter Hamilton he described the presence of tobacco dust in the vitreous cavity as an indicator of a retinal tear.\(^{27}\) Unfortunately this sign which was independently recognised by Shaffer is more commonly referred to as Shaffer's sign.\(^{28}\)

Taylor's first passion was medical retina but he continued performing retinal surgery with skill until he retired for the second time at the age of 60.

4.7 Vitreous Surgery.

The first account of vitreous surgery being performed in New Zealand was in Wellington by Barrie Jones in 1949. The case report described a young boy with a retained non-magnetic intra-ocular foreign body in an eye with opaque media. Jones devised a method whereby an
electromagnetic current applied to the base of a pair of forceps could be tuned to providing an audible signal as the forceps approximated the foreign body. Indeed the forceps were able to be directed to the foreign body, sight unseen and allow for a successful removal. This apparatus was further adapted by Keeler in London and subsequently marketed as the Roper-Hall Foreign Body Locator.

The first planned vitrectomies were performed in New Zealand by O.B Hadden in 1976. The vitrectors of this era were multi-functional and contained within a single hand piece both vitreous cutter and infusion line. These instruments were called a vitreous infusion cutter or VISC. The cutter was powered by a motor in the hand piece and aspiration controlled by an assistant who created negative pressure by aspirating on a syringe. The intra-ocular pressure (IOP) was regulated by adjusting the height of the infusion fluid, usually Hartmanns. The light source was initially sourced from Storz but the fibre optic was limited in both manoeuvrability and brightness. The microscope did not have an X-Y movement but irrigating contact lenses were available.

The indications for surgery were limited and whilst there was an intra-ocular cryo probe available by the late 70s most surgeries were limited to clearing vitreous haemorrhage and eyes where there was thought to be traction on the retina preventing re-attachment. The first case reports were reported in the Transactions of the Ophthalmic Society of New Zealand in 1977. Bowbyes who was then resident in Dunedin reported on 7 eyes with good results while Hadden reported on a similar number from Auckland.

Hadden was the first New Zealander who received sub-specialty training in retina in the United States, an indication in the perceptible shift of influence across the Atlantic. Hadden and Taylor both practiced in Auckland and subsequently joined forces and formed the first New Zealand private retinal sub-speciality group. They invested in contemporary technologies acquiring a suite for fluorescein angiography and argon laser photocoagulation.
They were instrumental in the shift to 3 port vitrectomy and acquired for both public and private sectors the new Ocutome vitrector.\textsuperscript{(33)} This instrument, revolutionary \textit{at the time}, provided for \textit{automated and controlled} aspiration, utilised a reusable cutter and was equipped with a halogen/suitable light source. Many other centres in New Zealand subsequently acquired this technology. \textit{In the 1980s} Grieshaber introduced the air pump enabling an easier fluid air exchange. An air pump was subsequently incorporated into the next \textit{generation} vitrectomy machine, called the \textit{Series 10,000} and was manufactured by Alcon Laboratories.

While patients with advanced diabetic eye disease remained a common indication for vitrectomy surgery, it was \textit{not until 1990} that a laser with a facility for intra-ocular use became available in New Zealand. Diabetic patients who were likely to require intra-operative laser photocoagulation had to apply \textit{for funding} and seek treatment abroad, most often in the United States. In the late 1980s 2 to 3 patients per year sought such assistance. Ultimately in response to repeated requests, the \textit{Ministry of Health} provided funding for the purchase of a laser with both an endolaser and laser indirect facility. The Novis was made by Coherent and was relatively mobile at 120Kg. The \textit{quid pro quo} was that Auckland became the tertiary referral centre for vitreo-retinal surgery in New Zealand. This state of affairs did not persist for long as other centres, Christchurch, Hamilton, Wellington and more recently Tauranga attracted ophthalmologists with vitreo-retinal expertise.

In the last 10 years there has been an increase in \textit{resources} provided to vitreo-retinal surgery in New Zealand. This in turn has fostered the development of formal research programs within the country and created an environment where \textit{the unique} problems confronting New Zealand may be answered.
Section I Chapter 4

4.8 Acknowledgements.

I am grateful to those senior colleagues who provided the background material for this paper, particularly those who took the trouble to collect cases and write of their experiences in the fledging Transactions of the Ophthalmic Society of New Zealand. I am indebted to Mr R Keeler FRCOphth (Hon), Curator of the Historical Section at the Royal College of Ophthalmologists.
4.9 References.


Section II:

Clinical Investigations
Chapter 5: Epidemiology of Rhegmatogenous Retinal Detachment in New Zealand.

5.0 Summary.

Introduction: The incidence of retinal detachment in New Zealand has not been surveyed recently. This study sought to determine the annual incidence of RRD in Northern New Zealand and identify, if possible, associated risk factors.

Methods: Epidemiological and clinical data were collected for all patients presenting with a RRD in a 12-month interval in a confined geographical area of New Zealand.

Results: One hundred and forty one patients presented between May 1997 and April 1998 with a RRD. Five patients presented with bilateral RRD. The mean age at presentation was 53.9 years and the annual incidence for RRD was 11.8 cases per 100,000 people. RRD was more common in males than in females (1.3:1). Ocular trauma, high myopia and cataract extraction were found to be significant risk factors in the development of RRD.

Conclusion: The annual incidence of RRD in Northern New Zealand is comparable to values reported for other parts of the world and broadly consistent with the findings of a previous study performed 40 years ago in Christchurch.

The incidence of RRD was found to increase with age, and in association with trauma, high myopia and cataract surgery.
5.1 Introduction.

RRDs are an uncommon cause of ocular morbidity. In most parts of the developed world, patients presenting with retinal detachments are referred to those ophthalmologists with surgical retinal expertise. This approach, in a time of budgetary constraints, means resources and personnel should be balanced with need. Part of the matching process involves collection of epidemiological data and evaluating risk. Recent studies have noted a RRD incidence of 5-14 people per 100,000 per year. Similarly, studies have estimated the prevalence ranges between 3-5 per 10,000.

The major risk factors for developing a RRD include high myopia, ocular trauma, cataract surgery, and increasing age. The Northern New Zealand Retinal Detachment Study evaluated, in a prospective manner, the incidence of RRD in a geographically limited region and evaluated demographic data along with ocular findings.

5.2 Materials and Methods.

(i) Northern NZ Retinal Detachment Study.

The area of study covered the Northern half of the North Island of New Zealand, home to 1.2 million people. Data was collected over a twelve-month interval, (June 1997 – May 1998) in a prospective fashion on all patients presenting with a RRD. This area of New Zealand is circumscribed geographically with the majority of the population living in a single urban area. An adjacent city 200km south of the study area with a surgical retinal facility screened all patients presenting to that service for any patients domicile in the study area. No such patients were identified. There were 7 retinal specialists who participated in the study.
(ii) **Inclusion Criteria.**

A *rhegmatogenous* retinal detachment was defined as a break in the retina, which allowed fluid vitreous to enter the sub-retinal space and extend for at least 2 disc diameters. Included in the study were patients with a history of trauma, previous retinal detachment and retinal tears. We did not exclude patients with previous intra-ocular surgery. Patients with combined *tractional rhegmatogenous retinal detachments as seen in diabetics* were excluded from the study. Similarly, patients with localised sub-retinal fluid associated with macular holes were also excluded.

Patients presenting with a recurrent RRD within 4 months of any primary repair were considered to have failed surgery and were recorded separately. This necessitated data collection for a 16-month window.

(iii) **Demographic Resources.**

The NZ Department of Statistics conducted a compulsory census in March 1996. Our study was completed in May 1998. We have based our statistics on the NZ Census and calculated an overall incidence rate for retinal detachment within the population under study using direct age standardisation. Incidence rates for sex and age together with other demographic data have been drawn from this information.

The relative importance of gender, degree of myopia, history of trauma, history of cataract surgery, and whether it was complicated, in developing RRD was modeled using a Cox proportional hazards model. All variables were entered into the model and the best subset of independent predictors discovered using a stepwise procedure. Choice of the final model was based upon the statistical significance of the parameter (p<0.05), biological plausibility and parsimony. All tests were two-tailed.
5.3 Results.

There were 146 new RRD cases, which presented in 141 patients, comprising 61 women and 80 men. The overall incidence rate was 11.8 (CI; 9.8 to 13.7) per 100,000 people. The patients’ ages ranged from 5 to 96 years with a mean age (± standard deviation) of 53.9 (±19.6) years. The incidence of retinal detachment was maximal in the 60 to 69 year age group (Figure 5-1) with a predominance of females in the first half of this decade (59%), and males in the latter (65%).

Figure 5-1: The age distribution of patients presenting with rhegmatogenous retinal detachments in Northern NZ, relative to the general population. Approximately half the patients presenting with a RRD do so by the age of 59 years (95% confidence interval 54-62 yrs).

Overall, retinal detachment presented more commonly in males at a ratio of 1.3:1. (Table 5-1).
Table 5-1: Actual numbers and incidences of retinal detachment within the Northern NZ population for males, females and all individuals.

<table>
<thead>
<tr>
<th>Age range</th>
<th>No. of males (NZ census)</th>
<th>No. of females (NZ census)</th>
<th>Total no. individuals with RRD in 1997/98</th>
<th>Incidence of RRD per 100,000 population</th>
<th>No. of males with RRD</th>
<th>Incidence of RRD per 100,000 males</th>
<th>No. of females with RRD</th>
<th>Incidence of RRD per 100,000 females</th>
</tr>
</thead>
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<tr>
<td>&lt;10</td>
<td>99,667</td>
<td>94,427</td>
<td>3</td>
<td>1.5</td>
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<td>1.1</td>
</tr>
<tr>
<td>10 to 19</td>
<td>88,859</td>
<td>85,207</td>
<td>5</td>
<td>2.8</td>
<td>4</td>
<td>4.5</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>20 to 29</td>
<td>91,031</td>
<td>97,315</td>
<td>18</td>
<td>9.6</td>
<td>9</td>
<td>9.9</td>
<td>9</td>
<td>9.2</td>
</tr>
<tr>
<td>30 to 39</td>
<td>97,181</td>
<td>103,192</td>
<td>8</td>
<td>4.0</td>
<td>2</td>
<td>2.1</td>
<td>6</td>
<td>5.8</td>
</tr>
<tr>
<td>40 to 49</td>
<td>81,961</td>
<td>85,697</td>
<td>14</td>
<td>8.4</td>
<td>9</td>
<td>11.0</td>
<td>5</td>
<td>5.8</td>
</tr>
<tr>
<td>50 to 59</td>
<td>56,568</td>
<td>57,090</td>
<td>26</td>
<td>22.9</td>
<td>17</td>
<td>30.1</td>
<td>9</td>
<td>15.8</td>
</tr>
<tr>
<td>60 to 69</td>
<td>39,765</td>
<td>40,716</td>
<td>40</td>
<td>49.7</td>
<td>22</td>
<td>55.3</td>
<td>18</td>
<td>44.2</td>
</tr>
<tr>
<td>70 to 79</td>
<td>25,309</td>
<td>32,930</td>
<td>19</td>
<td>32.6</td>
<td>11</td>
<td>43.5</td>
<td>8</td>
<td>24.3</td>
</tr>
<tr>
<td>over 80</td>
<td>9,623</td>
<td>19,156</td>
<td>8</td>
<td>27.8</td>
<td>4</td>
<td>41.6</td>
<td>4</td>
<td>20.9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>589,965</strong></td>
<td><strong>615,729</strong></td>
<td><strong>141</strong></td>
<td><strong>11.7</strong></td>
<td><strong>80</strong></td>
<td><strong>13.6</strong></td>
<td><strong>61</strong></td>
<td><strong>9.9</strong></td>
</tr>
</tbody>
</table>

Ethnicity was not evaluated in this study. In this series most of the patients were in good health. Cardiovascular disease was recognised in 12% and respiratory disease, most commonly obstructive airway disease, was found in 5%. Over 13% (n=19) of our patients were smokers. The age of patients who smoked ranged from 18 to 79 years. Voluntary disclosure of smoking in the 1996 Census confirmed a comparable percentage (14.2%) with the participants in the current study.

Ocular trauma preceded RRD in 16.4% of patients. The majority of these patients had severe ocular trauma including penetrating eye injury; cataract wound dehiscence and globe rupture. Interestingly, 87.5% of those in the trauma group were under the age of 50 years, whilst this age group comprised only 35.6% of the total number of RRDs. The relationship between RRD and non-ocular trauma was not explored.
A number of patients presented with a history of surgical retinal disease. Thirteen patients gave a history of treated retinal tears in the eye presenting with RRD while 5 patients had tears previously recognised in their fellow eyes. Twelve patients had previous RRD in their presenting eye and another 9 patients had involvement of their non-presenting eye. Five patients presented in this series with bilateral retinal detachments.

We defined high myopia as that greater than 6.0D. Thirty-three patients had myopia of this magnitude, some 23% of our patients.

Forty-eight, or 33%, of eyes presenting with RRD had undergone cataract surgery. Two-thirds (n=31) of the 48 eyes had undergone phaco-emulsification as the method of cataract extraction with another 11 by extra-capsular surgery. In 6 eyes the method of lens extraction could not be determined. In Figure 5-2 the time interval between cataract surgery and the retina detaching is shown. The longest interval was 38 years but almost 50% of detachments post cataract surgery occurred within 2 years of the cataract surgery, and approximately 75% of these were within 12 months of surgery. The numbers of patients having had evidence of YAG capsulotomy was too small (n=5) for statistical analysis.
Figure 5-2: Distribution of times to retinal detachment following cataract surgery, differentiating those that were considered complicated (green bars) vs. those that were considered uncomplicated cataract surgery (blue bars).

There was no demonstrated increased risk of developing a retinal detachment with complicated cataract surgery.

Univariate statistical models showed that having RRD earlier in life was associated with trauma, myopia greater than 6 dioptres, and the previous cataract surgery but not male gender. In a multivariate Cox proportional hazards model of the risk of early RRD there was a four-fold increase in the risk of early RRD in those experiencing trauma (4.1 95% CI 2.6-6.6, \( p=0.0001 \)). Independently, myopia beyond 6D increased the risk of early RRD 90% (1.9 95% CI 1.2-2.8, \( p=0.0024 \)) while previous cataract surgery independently increased the risk of early RRD 90% (1.9 95% CI 1.3-2.7, \( p=0.0008 \)). Gender was not independently associated with early RRD (\( p=0.64 \)).

We attempted to evaluate, in those patients who had had cataract surgery, whether there was evidence of complicated surgery. Options included displaced intra-ocular lens, vitreous in the anterior chamber, peaked pupil, ruptured posterior capsule or simply “complicated non-
specific”. Fifteen patients were thus defined as having had complicated cataract surgery. Two-thirds of these patients developed a RRD within 2 years of their cataract surgery, but the range was from 3 weeks to 29 years. Comparing the time interval for developing a RRD in this subset of patients highlighted no statistically significant difference from those patients deemed to have had uncomplicated cataract surgery (p<0.05).

5.4 Discussion.

Forty years ago Suckling et al reported on the incidence of RRD in the Christchurch area and found the incidence was 1 in 20,000 per year.

This current study found the annual incidence of RRD in Northern New Zealand is approximately 12 per 100,000 population (CI 10-14 per 100,000). This figure includes all patients presenting with retinal detachments and not solely those progressing to surgery. However we did not include patients undergoing repeat surgeries within 4 months of any primary repair even if the break was at a site distant from the original pathology.

We believe that, because of the circumscribed area, the active support of the ophthalmic community, and access to both private and public patients, our report reflects accurately the absolute number of patients with RRD in Northern New Zealand.

Similar studies documenting the incidence of RRD have reported both higher and lower annual rates than we have documented.(1-3) Some of these differences may be explained by varying methods of data collection. For example, some authors restricted their surveys to patients undergoing retinal re-attachment surgery, while others have excluded RRD following trauma and intra-ocular surgery. The Olmsted County Study included all patients presenting with RRD over a 20-year interval and found an annualised incidence rate of 17.9 per
100,000.\(^{(8)}\) This group did not exclude failed primary surgeries, which may account for their overall higher rate. However, this report did include aetiological groupings and age stratification, allowing for further comparisons with our data. (Figure 5-3)

**Figure 5-3:** Incidence rates of RRD among residents of Northern NZ (1997-1998) compared with residents of Olmsted County, Minnesota (averaged 1976-1995) \(^{(7)}\) by age and type of retinal detachment.

The rates of RRD in our study group were consistently lower for all groupings (idiopathic, trauma, and following cataract surgery) with the exception of the pseudo-phakic population between the ages of 60 and 80, where the incidence was somewhat higher in the current study. The comparison of the data from the current study with that from Örebro and Värmland in Sweden is more difficult due to the limited age stratification and absence of gender separation used in the latter study.\(^{(2,8)}\) However a meta-analysis performed for the three studies, based on the age stratification used in the Swedish study, can be performed. (Table 5-2)
Table 5-2: Comparison of the incidence rates of RRD (per 100,000 persons per year) in Olmsted County, Minnesota, USA (averaged 1976 - 1995), Örebro and Värmland, Sweden (averaged 1976 - 1980) and Northern New Zealand (1997 – 1998), according to age.

<table>
<thead>
<tr>
<th>Age</th>
<th>Olmsted (n = 311)</th>
<th>Sweden (n = 289)</th>
<th>New Zealand (n = 141)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 29</td>
<td>5</td>
<td>2.3</td>
<td>4.7</td>
</tr>
<tr>
<td>30 - 59</td>
<td>18.3</td>
<td>10.4</td>
<td>10</td>
</tr>
<tr>
<td>60+</td>
<td>49.7</td>
<td>27.9</td>
<td>40</td>
</tr>
</tbody>
</table>

This highlights that the pooled annual incidence (weighted by the inverse of their variance) is approximately 12.9 per 100,000. Although this is not separated by gender it would appear that the incidence of RRD is lower in those aged over 60 in the Swedish study than it is in Northern New Zealand or in Olmsted County, USA (p<0.05 in both cases). No other difference reached conventional statistical significance.

The observation that the relative risk of RRD increases with age for both sexes has been confirmed in the current study. Males developed RRD at a rate of 1.4 per 10,000 patient years while females developed RRD at a rate of 1.0 per 10,000 patient years. The difference between the genders was not statistically significant, however.

The results of the current study, consistent with previous studies, highlighted that ocular trauma, previous cataract surgery, and high myopia (>6D) were risk factors in the development of retinal detachment.
The Eye Disease Case-Control Study Group reported myopia as the single most relevant risk factor in the causation of idiopathic RRD, and conceivably this may account for lower numbers in the current study population if the prevalence of myopia is lower in the study area.\(^9\) Unfortunately the prevalence of myopia in New Zealand has not previously been documented in the literature.

Similarly we do not have access to numbers in the study population who have undergone cataract surgery but suspect like others, cataract surgery increases the risk of RRD.\(^1, 2\) Most of the patients in the current study had undergone phaco-emulsification and almost one-third (\(n=15\)), were identified as having had complicated cataract surgery, a proportion which is well above the national average phaco-emulsification complication rate of around 5\%\(^10\). Ten of these 15 developed RRD within 2 years, and nine were within 1 year. Both the Olmsted County Study and the International Cataract Surgery Outcomes Study demonstrated that the probability of RRD following cataract surgery was around 5.5 to 7.6 times the risk for a phakic eye.\(^8, 11\) These studies did not evaluate the risk of RRD associated with complicated cataract surgery but this association is recognised and is believed to account for the sharp increase in frequency of RRD in the peri-operative period.\(^1, 3, 4\) Our data does not enable us to reach any conclusion as to the perceived increase risk of RRD following cataract surgery, nor does it identify complicated cataract surgery as a heightened risk factor.

Previous retinal pathology, including a history of retinal detachment and / or retinal tears, was recorded in many of the patients in the current study. Tornquist reported on rates of bilateral RRD over a 10-year period in Sweden and noted a prevalence of 11.2\%, a much higher rate than the figure of 3.5\% in the current study.\(^12\) The Swedish study also recorded those patients with a history of RRD in their presenting eye. They excluded cases with a recurrent RRD and
a history less than six months from the original surgery (compared with 4 months in our series) and reported a rate of 6.4%, compared to our rate of 8.2%. The frequency of bilateral and recurrent disease does not answer the debate on the merits of prophylaxis but highlights, for the individual patient, a need to be aware of the symptoms of retinal disease.

In summary, this report confirms that the risk of RRD is related to age, cataract surgery, myopia and a history of ocular trauma.
5.5 References.


Chapter 6: Analysis of Symptoms Associated with Rhegmatogenous Retinal Detachment.

6.0 Summary.

Background: The relationship of the constellation of symptoms associated with retinal detachment is poorly understood.

Objective: To determine the frequency and type of symptoms associated with RRD and analyse the relationships with the pre-morbid state.

Methods: A written questionnaire together with clinical data was collected for patients presenting with RRD. (Appendix 1)

Results: The data on 141 patients presenting with RRD were evaluated prospectively. More than 90% of patients reported a variety of symptoms including visual loss, floaters and flashes. The speed of visual loss was not associated with location or extent of retinal break. Those patients with a history of retinal pathology were not any more likely to be symptomatic either in their presenting or fellow eye. The absence of symptoms was not associated with age or high myopia.

Conclusion: Symptoms are a useful indicator of RRD but this study suggests the sensitivity in certain groups is not high and other screening methods may be more reliable.
6.1 Introduction.

The visual outcome following successful retinal re-attachment surgery depends not only on the pre-operative findings but also the morbidity associated with the surgery. Many techniques have been developed to minimise the risk of surgery and to prevent the development of co-morbid pathologies such as cataract and ocular hypertension. A key indicator for visual outcome following retinal re-attachment surgery is the status of the macula. Retention of good central visual function is the norm if the macula is attached at the time of surgery, but once the macula detaches, less than 75% of patients will achieve 6/12 or better. Furthermore, rapid surgical intervention in the presence of a detached macula does not improve the visual prognosis.

Regrettably, many patients do not present until after macula detachment and this delay in presentation prompted us to review the symptoms reported by patients in the evolution of a RRD.

Not all patients presenting with RRD report premonitory symptoms and unfortunately many of the symptoms associated with retinal detachment are not specific and overlap with both ageing changes in the vitreous as well as posterior vitreous detachment (PVD) and retinal breaks. Furthermore, whilst PVDs and retinal tears are important in the genesis of RRD, not all progress to a sight-threatening RRD.

6.2 Methods.

The 141 consecutive patients enrolled in this study have been detailed in the previous chapter. All patients underwent a detailed history and examination with particular care taken during the enquiry to determine the presence or absence of symptoms. The type, number, duration
and evolution of symptoms were recorded on a standardised recording sheet for consistency between examiners.

In the current study the mean age at presentation was 53 years with a standard deviation of 19.6 years. The ratio of males to females was 1.3:1.

Thirty four per cent of the patients had undergone cataract surgery prior to the development of the RRD, and 29% of the remaining phakic patients were myopic. Five patients presented with bilateral RRD so there were 146 eyes available for the present study.

A number of patients had a history of surgical retinal disease including retinal tears and RRD. (Table 6-1) We excluded only those eyes with recurrent RRD in their presenting eye when the detachment recurred within 4 months of the previous surgery.

Table 6-1: Absolute numbers of patients with a history of retinal disease in the presenting and fellow eye.

<table>
<thead>
<tr>
<th></th>
<th>Presenting Eye</th>
<th>Fellow Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated Retinal Tears</td>
<td>N = 13</td>
<td>N = 5</td>
</tr>
<tr>
<td>Retinal Detachment</td>
<td>N = 12</td>
<td>N = 9</td>
</tr>
</tbody>
</table>

Statistical analysis was performed using SPSS (SPSS, Chicago, IL, USA). Relationships between normally distributed parameters were established using linear regression analysis, and differences between parameters were determined by analysis of variance (ANOVA). A significance level of 5% was used throughout.
6.3 Results.

Most of the patients in this series experienced entoptic phenomena prior to the diagnosis of RRD. Only 14 of the 146 eyes were asymptomatic, being detected on routine review by their ophthalmologist or primary health care provider in the vast majority of cases. The ophthalmic findings are summarised in Table 6-2. Eight of these 14 eyes presented with the macula attached; however pre-existing macular pathology was present in half of these eyes with poor central acuity. Those patients with good acuity yet who were asymptomatic had either a peripheral detachment such as a dialysis or evidence of a chronic detachment such as atrophic retina, pigment lines, or sub-retinal bands. One patient included in the asymptomatic group developed a giant retinal tear (GRT) as a complication of cataract surgery and had retinal surgery the same day. Of the 5 patients (3.5%) who presented with bilateral RRD, 3 patients were symptomatic in both eyes but the remaining 2 were asymptomatic in their fellow eye.

Table 6-2: Ocular features in asymptomatic patients.

<table>
<thead>
<tr>
<th>Asymptomatic Cases</th>
<th>No. of eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macula-on</td>
<td>8</td>
</tr>
<tr>
<td>VA &lt; 6/36</td>
<td>4</td>
</tr>
<tr>
<td>VA &gt; 6/36</td>
<td>4</td>
</tr>
<tr>
<td>Macula-off</td>
<td>6</td>
</tr>
<tr>
<td>Previous retinopexy in presenting eye</td>
<td>2</td>
</tr>
<tr>
<td>Previous retinal detachment in presenting eye</td>
<td>3</td>
</tr>
<tr>
<td>Asymptomatic fellow eye in bilateral presentation</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
</tr>
</tbody>
</table>

VA = visual acuity
Further analysis of those patients with asymptomatic RRD revealed no statistically significant relationship with symptoms, age, sex, myopia or previous cataract surgery.

Included in this study were 18 patients who had a history of retinopexy for presumed retinal breaks. The retinopexy had been applied to the presenting eye in 13 patients, while 5 patients had treatment to the fellow eye. This sub-group of patients were no more likely to be symptomatic than those patients without a history of retinopexy. However, a statistically significant difference was established between those patients with and without a history of previous retinal detachment repair and, rather unexpectedly, patients with a history of RRD were more likely to be asymptomatic. (ANOVA $F = 5.873, p = 0.017$). The patients with symptomatic RRD reported a variety, and often a combination of symptoms including flashes, floaters, and shadows of varying intensity, loss of vision, dyschromatopsia, and ocular pain. The number and variety of symptoms for those patients reporting either one or two symptoms are recorded in Table 6-3. There were 112 symptomatic patients reporting 1 or 2 symptoms. This table details those patients.

**Table 6-3:** Number of patients with a RRD and reporting up to two symptoms prior to the presentation with RRD.

<table>
<thead>
<tr>
<th></th>
<th>Flashes</th>
<th>Floaters</th>
<th>Shadow</th>
<th>Loss of vision</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashes</td>
<td>1</td>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Floaters</td>
<td></td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Shadow</td>
<td></td>
<td></td>
<td>8</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td>Loss of vision</td>
<td></td>
<td></td>
<td></td>
<td>39</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

**Bold type,** patients reporting a single symptom; not bold, patients declaring two symptoms.
Fourteen patients had a combination of 3 symptoms and 6 patients reported 4 symptom types. Some patients reported an evolving pattern of symptoms but no consistent pattern emerged in either the group as a whole or any subset.

Forty-one patients gave a history of floaters, which varied from small mobile dark dots to undulating obscurations that covered much of the visual field. There was no statistically significant relationship established between a history of floaters, the age or gender of the patient, or myopic status, history of previous cataract or retinal pathology.

Most of the patients (65%) with floaters presented within 7 days of becoming symptomatic but the range was from 1 to 70 days.

Flashes, when reported, were typically silvery, in the temporal field and were most prominent under mesopic conditions. The duration of the flashing lights varied from 1 day to 6 months. Approximately half of the patients (55%) experienced flashing lights for a week or less. Those patients with flashing lights (n=22) reported that this symptom persisted until presentation whereas many patients reported that the floaters disappeared with time.

A few patients (n=3) reported dyschromatopsia, typically a greenish hue and this symptom tended to precede the development of a shadow. Once the shadow developed the dyschromatopsia vanished.

Description of shadows or curtains, peripheral obscurations was reported in 53 eyes prior to presentation with RRD. The evolution of this symptom varied considerably (between 1 and 21 days), however, the vast majority of patients (86.8%) presented within 7 days of becoming symptomatic. There was no statistically significant relationship between the location of the retinal break and the extent of the break (ANOVA, P= 0.801), but the shadow duration was
related to the retinal break location such that superior breaks progressed more rapidly than
inferior breaks (3.8 ± 3.3 days compared with 6.9± 6.2 days; ANOVA, P= 0.023)

There was no statistically significant correlation between the extent of the retinal break and
shadow duration. (R² = 0.026, P = 0.264) Similarly, in phakic eyes the shadow did not progress
any faster or slower than pseudo-phakic or aphakic eyes. (ANOVA, p = 0.223)

Nine patients reported an ocular or peri-ocular pain prior to presenting with a retinal
detachment. This symptom lasted for up to 14 days and typically was of a diffuse, boring
nature. It was not severe. In the majority of these patients this symptom preceded all others.
The single commonest symptom was loss of vision (n = 82) and patients reported a history
extending from 1 to 36 days. Most patients (84.1%) presented within a week of losing vision.

Having established that as a group those patients with a history of RRD were more likely to
be asymptomatic, we attempted to define what symptom groupings were more likely to be
associated with previous RRD. There was no clear difference between those patients with and
without a history of a RRD but there was a trend towards a higher proportion of patients,
having already had an RRD, to being asymptomatic with their subsequent RRD. Overall, of
those patients without a history of RRD, 92.8% noticed at least one symptom, while of those
patients with a positive history only 76.2% noticed one or more symptom. (Table 6-4)

<table>
<thead>
<tr>
<th>Table 6-4: Comparison of symptoms and history of RRD.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Noticed no symptoms</td>
</tr>
<tr>
<td>Noticed 1 symptom</td>
</tr>
<tr>
<td>Noticed 2 symptoms</td>
</tr>
<tr>
<td>Noticed 3 symptoms</td>
</tr>
<tr>
<td>Noticed 4 symptoms</td>
</tr>
</tbody>
</table>
Patients with a history of RRD were more likely to be asymptomatic than those who were presenting with a retinal detachment for the first time (P=0.017). Conversely no significant difference was found in those sub-groups of patients who were symptomatic.

6.4 Discussion.

In screening for patients with RRD it would be useful to determine which symptoms are important and if they can be distinguished from the symptoms associated with PVD and other ophthalmic conditions. Current evidence suggests that symptoms alone are unlikely to be specific enough to be reliable indicators of RRD, and that additional modifiers such as age, history of intra-ocular surgery, myopia and previous retinal pathology are required. Certainly isolated symptoms of flashes, floaters, progressive field defects, ocular pain or dyschromatopsia can equally be associated with other pathologies such as ischaemic optic neuropathy, vitreous syneresis or detachment, retinal tears and vitreous haemorrhage. (15-19)

In the current study more than 90% of the 141 patients presenting with a RRD reported a variety of symptoms, with about half presenting a combination of symptoms. The single most frequently reported symptom was loss of vision. Furthermore, loss of vision was also most commonly experienced by those patients with 2 or more symptoms.

Tanner et al have also analysed the type and frequency of symptoms associated with RRD. In their study they excluded patients who had undergone previous intra-ocular surgery, such as cataract surgery as well as those with a history of retinopexy or previous retinal re-attachment surgery. (13) In our series we did not exclude these patients as approximately one third of patients presenting with RRD have undergone cataract surgery. (20, 21) Furthermore, we have also included patients with a history of previous surgical retinal pathology, as again these patients can present with recurrent disease, either in the eye with the original pathology or fellow eye. (22-24) Indeed, in our series this group of patients accounted for nearly 20% of the
patients surveyed. We did exclude those eyes with recurrent retinal detachment who represented within 4 months of the initial treatment, categorising these patients as failed primary surgery.

In spite of the different selection criteria, we found certain qualitative but not quantitative similarities between our study and that of Tanner et al.\textsuperscript{(13)} Field or visual loss was the most frequent symptom in both studies, while asymptomatic RRD was relatively uncommon.

In the Duke Elder lecture of 1989, Scott reported on a study conducted in his department reviewing the symptoms of 50 consecutive patients presenting with RRD.\textsuperscript{(11)} Like our study, this group did not exclude patients with previous cataract surgery and found patients reported a constellation of symptoms including peripheral flashes, scintillations, floaters, field loss and blurring. Seven (14\%) patients in this survey were asymptomatic.\textsuperscript{(11)} Scott has subsequently emphasised the importance of blurring of vision and field loss in patients with RRD. (Scott J, personal communication 2003)

Our study confirmed the observation that patients with bilateral RRD need not be symptomatic in both eyes.\textsuperscript{(25)} Furthermore, Brod et al demonstrated that patients with bilateral but asymptomatic RRD can progress and may require treatment.\textsuperscript{(26)}

In 1973 Davis described an entity which he called sub-clinical retinal detachment.\textsuperscript{(27)} This was defined as a retinal detachment that extended for more than 1 disc diameter from the retinal break, but no more than 2 disc diameters posterior to the equator. Davis found one-third of those eyes with sub-clinical retinal detachment progressed to requiring surgery.

Conversely Byer, when studying the natural history of asymptomatic retinal breaks, noted a sub-group of 17 eyes with sub-clinical retinal detachments. During a period of observation ranging up to 12 years none progressed to require surgery.\textsuperscript{(17)} The benign nature of the
asymptomatic retinal detachments in Byer’s series may be due to multiple factors and while the patients were drawn from a non-selected general population, patients with a history of intra-ocular surgery and previous retinal pathology were excluded.

Cohen has also documented the natural history of asymptomatic retinal detachments and noted the risk of progression is low.\textsuperscript{28} He further postulated that asymptomatic RRD may represent a sub-group of patients where the forces of detachment are balanced by the forces of re-attachment. This proposition has been challenged and it is likely at least with some patients that the presence or absence of symptoms depends more on the observational and cognitive powers of the patient than the underlying retinal pathology.\textsuperscript{29}

In the present series, 10\% of the patients had asymptomatic RRD and included eyes with high risk features such as previous retinal detachment, high myopia, and a history of cataract surgery. Indeed, patient self-awareness of a RRD was not greater in that cohort who had previously experienced a RRD, in either the presenting or fellow eye. This observation would support the view that regular review of all patients with a history of RRD is prudent although the question of the timing of such reviews is clearly not answered in this study.

The absence of symptoms in some patients with RRD should not negate any public health education programme designed to alert the 90\% of patients who will develop symptoms during a retinal detachment.\textsuperscript{30} However the absence of symptoms does highlight the need for the ophthalmologist to be aware that not all patients with RRD are symptomatic.
6.5 References.


Chapter 7: Rhegmatogenous Retinal Detachment following Cataract Surgery.

7.0 Summary.

Background: Cataract surgery is associated with an increased risk of RRD but there are few reports describing the relationship of RRD and cataract surgery using phaco-emulsification techniques.

Objectives: To determine the incidence of RRD following cataract surgery in New Zealand.

Methods: A retrospective study approximating 1,800 consecutive patients undergoing cataract surgery from the early 1990s was undertaken. Ten years after the original surgery the ophthalmic records of these patients were reviewed and those patients developing RRD were identified.

Results: The overall risk of RRD following cataract surgery is approximately 1% with a peak incidence occurring within 2 years of the cataract surgery. Patients under the age of 50 years had an increased risk of RRD as did those eyes with axial myopia.

Conclusion: Cataract surgery in New Zealand carries a relatively low risk of RRD.
7.1 Introduction.

The causal relationship between cataract surgery and RRD has been the subject of intensive investigation for a number of years.\textsuperscript{(1-4)} One analytical approach used to evaluate whether there is an increased risk of RRD following cataract surgery has been to determine the prevalence of RRD in the phakic population and compare the rate in the aphakic or pseudo-phakic population.\textsuperscript{(5,6)} Other studies have attempted to identify what sub-groups undergoing cataract surgery are at greater risk.\textsuperscript{(7,8)} To date, no studies have explored the relationship between RRD and patients with visually significant cataracts who have not undergone surgery.

7.2 Association of Cataract Surgery with Rhegmatogenous Retinal Detachment.

Many of the formative studies defining the link between RRD and cataract surgery were based on techniques popular in the 1970s and 80s.\textsuperscript{(4,9)} The technique of intra-capsular cataract surgery and the subsequent technique of extra-capsular surgery have been superceded as has the notion of leaving the patient aphakic.\textsuperscript{(10)} However these early studies remain relevant as a benchmark for the current approach of utilising ultra-sonic energy to remove the cataractous lens. Furthermore, these early studies revealed that aphakic or pseudo-phakic RRD could occur some years after the indicative surgery.\textsuperscript{(1,11,12)}

No randomised studies are available to compare the incidence of RRD following intra-capsular and extra-capsular cataract extraction but most studies evaluating RRD following the shift to extra-capsular surgery report a reduction in RRD.\textsuperscript{(2,3,13,14)} The reported incidence of RRD in patients having intra-capsular surgery range from 1-8.1% while for those having extra-capsular surgery the risk ranges from 0 to 7.5%.
This observation together with a reduction in other intra- and post-operative complications accelerated the change in methodology of cataract surgery. The parallel developments occurring in posterior chamber intra-ocular lens technology meant that by the early 1980s intra-capsular cataract surgery was no longer being regularly performed in the developed world. (15)

### 7.3 Changes in Cataract Methodology.

The shift to extra-capsular surgery with nuclear expression was subsequently surpassed by phaco-emulsification in the early to mid 1990s. Although the concept of using ultra-sonic energy to remove a cataractous lens had been devised by Kelman in 1967, this method of
cataract surgery did not become popular until refinements in technique and instrumentation occurred.\(^{(16)}\) By the year 2000 in excess of 95% of patients undergoing cataract surgery had their lenses removed by this technique.\(^{(17)}\)

**Table 7-3:** Changing pattern in methodology of cataract surgery.

<table>
<thead>
<tr>
<th>Year</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>Predominantly ICCE without IOL implantation (^1)</td>
</tr>
<tr>
<td>1980</td>
<td>Popularisation of ECCE surgery and IOL implantation (^2)</td>
</tr>
<tr>
<td>1990</td>
<td>Introduction of phaco-emulsification</td>
</tr>
<tr>
<td>1997</td>
<td>Equal ratio of phaco-emulsification and ECCE 1:1 (^3)</td>
</tr>
<tr>
<td>2001</td>
<td>Ratio of phaco-emulsification to ECCE 3:1 (^3)</td>
</tr>
<tr>
<td>2004</td>
<td>Ratio of phaco-emulsification to ECCE 4:1 (^3)</td>
</tr>
</tbody>
</table>

References:


The changing pattern of cataract surgery over the last 25 years has meant the linkages between RRD and cataract surgery have had to be revised. Furthermore, new hypotheses have had to be tested accounting for such variables as age, sex, and degree of myopia in addition to the changes in surgical technique. Koch highlighted an increased risk of RRD for patients that are male and high myopia was found to be an independent risk factor.\(^{(18, 19)}\) Leaving the patient aphakic as well as complicated surgery increased the risk of RRD in some series for both intra- and extra-capsular surgery.\(^{(20,22, 23)}\) The management of opacification of the posterior capsule was also implicated in the development of RRD.\(^{(24)}\) Although up to 50% of these capsules opacified in the peri-operative period, the retention of the posterior capsule facilitated the shift to posterior chamber intra-ocular lenses.\(^{(25)}\)
The high incidence of posterior capsular opacification prompted some surgeons to perform primary surgical discission at the time of cataract surgery.\textsuperscript{(19, 24)} Indeed the first major report describing the incidence of RRD following phaco-emulsification was based on a series where 95\% of the eyes had undergone primary discission.\textsuperscript{(26)} However the recognition that primary capsulotomy was associated with an increased risk of RRD and cystoid macular oedema together with the availability of the Nd:YAG lead to the abandonment of this approach.\textsuperscript{(27, 28)}

We have previously documented in our population one-third of patients presenting with RRD have undergone cataract surgery and most of these patients developed a RRD within two years of undergoing cataract surgery.\textsuperscript{(29)}

However, as a variety of surgical techniques had been used to remove the crystalline lens the conclusions of this study were limited. The current study attempts to define the risk of RRD for patients having cataract surgery by phaco-emulsification.

### 7.4 Materials and Methods.

The study was based on a retrospective review of all patients undergoing phaco-emulsification between Jan 1992 and Sept 1993. Patients under the age of 40 years and/or having cataract surgery following ocular trauma were excluded as well as those cases having planned or unplanned extra-capsular cataract surgery. Similarly, patients undergoing cataract surgery combined with other ocular procedures such as keratoplasty, glaucoma drainage surgery, or posterior segment surgery were excluded.

All the surgeries were performed at one institution and were identified from the operating room records. The operating surgeon was contacted and free access to the patients’ records was requested and in all cases granted. The demographic data and surgical details were recorded as was the patient’s last follow-up visit. Where available, the axial length and other
ophthalmic parameters were recorded together with any details of previous or subsequent ophthalmic history.

Every patient undergoing cataract surgery during the period of review was systematically cross-checked with the regions' vitreo-retinal database. In addition, the patient's name, date of birth, and National Health Index (NHI) number were matched against a database of all patients who had retinal detachment surgery performed at Auckland Public Hospital between January 1992 and January 2003. The end point of the study was 10 years from the date of the cataract surgery, or when the patient died. The relative importance of gender, age, axial length, complicated cataract surgery, and YAG capsulotomy were evaluated using the Fisher's Exact Test. A significance level of 5% was used throughout.

7.5 Results.

i) Demographics.

We identified 1,793 consecutive eyes in 1,547 patients who underwent phaco-emulsification cataract surgery during the period of review. Ten experienced cataract surgeons performed the surgeries using the Allergan Sensory V™. More than 95% of eyes had posterior chamber lenses inserted at the time of surgery.

Table 7-4: Intra-ocular lens (IOL) selection.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Surgeries (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior Chamber IOL</td>
<td>1,748 (97.5)</td>
</tr>
<tr>
<td>Anterior Chamber IOL</td>
<td>37 (2)</td>
</tr>
<tr>
<td>No IOL</td>
<td>8 (0.5) #</td>
</tr>
</tbody>
</table>

# denotes eyes where estimated post-operative refraction either approximated emmetropia or balanced the refraction in the fellow eye.
The mean age of the patients undergoing cataract surgery was 73.6 yrs (range 40 to 100 years). Five hundred and seventy three patients were men (37%), and 974 (63%) were women. Ninety five men and 161 women had second eye surgery during the study period. Three hundred and fifty eight patients (23%) died in the 10 year interval following the original cataract procedure, with the highest mortality in the over 70 age group. (Table 7-5)

Table 7-5: The relationship of the age of the pseudo-phakic patient and mortality.

<table>
<thead>
<tr>
<th>Age Group (years)</th>
<th>Number of Patients (%)</th>
<th>Number Died (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50</td>
<td>54 (3)</td>
<td>1 (&lt;1.0)</td>
</tr>
<tr>
<td>50 to 59</td>
<td>112 (7)</td>
<td>4 (&lt;1.0)</td>
</tr>
<tr>
<td>60 to 69</td>
<td>320 (21)</td>
<td>32 (2.0)</td>
</tr>
<tr>
<td>&gt; 70</td>
<td>1,061 (69)</td>
<td>321 (20)</td>
</tr>
</tbody>
</table>

ii) Risk of RRD.

There were 21 eyes that developed RRD following cataract surgery which equates to 1.17%. The interval between cataract surgery and development of a RRD ranged from 1-120 months with a median interval of 39 months. One fifth (4 out of 21) of RRD occurred within the first twelve months of surgery. The risk of developing a RRD was 5.17% for those patients under the age of 50 years, compared to 0.64% for those patients over the age of 70 years. This difference is statistically significant. (P=0.02)

Overall the incidence of RRD was higher in males (2.10%) compared to females (0.62%). (P=0.01).
iii) **Axial lengths.**

Axial lengths were available for 1,262 eyes. We analysed the distribution curve of axial lengths and arbitrarily assigned patients into two groups: those with axial lengths less than 24 mm and those greater than 24 mm. We found that the risk of RRD was 4.87 times higher for eyes which had an axial length measurement greater than or equal to 24 mm (P < 0.01). There were 71 eyes with axial lengths of 25 mm or greater and 2 of these eyes developed RRD. The sample size of this latter sub-group precludes any useful conclusions being drawn.

**Table 7-6: Correlation of RRD and axial length.**

Axial length measurements were available for 1,262 eyes. One RRD occurred in an eye without a readable axial length measurement.

<table>
<thead>
<tr>
<th>Axial Length (mm)</th>
<th>Number of eyes</th>
<th>Number of retinal detachments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 23</td>
<td>601</td>
<td>5</td>
</tr>
<tr>
<td>23 to 24</td>
<td>456</td>
<td>6</td>
</tr>
<tr>
<td>&gt; 24</td>
<td>205</td>
<td>9</td>
</tr>
</tbody>
</table>

In total, 95 eyes had a complicated surgical event equating to 5.2% of all surgeries. Thirty three eyes had posterior capsule rupture at the time of surgery including 24 eyes requiring an anterior vitrectomy. Two eyes that required an anterior vitrectomy developed a retinal detachment in the period of follow-up while another 2 eyes with capsule rupture also progressed to RRD. (Table 7-7)
Table 7-7: Absolute number of intra-operative complications that occurred during cataract surgery measured against retinal outcome.

<table>
<thead>
<tr>
<th></th>
<th>+ RRD</th>
<th>-RRD</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complicated Surgery</td>
<td>5</td>
<td>90</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Capsule Rupture</td>
<td>2</td>
<td>31</td>
<td>P=0.056</td>
</tr>
<tr>
<td>Anterior Vitrectomy</td>
<td>2</td>
<td>22</td>
<td>P=0.031</td>
</tr>
</tbody>
</table>

+ RRD (those eyes with a rhegmatogenous retinal detachment)  
- RRD (those eyes without a rhegmatogenous retinal detachment)


Three hundred and thirty two eyes had a Nd:YAG capsulotomy during the period of review. This did not lead to an increased risk for a RRD. (P=0.57) The mean age of this sub-group was similar to the overall group suggesting age was not a confounding factor. Furthermore, eyes with axial lengths greater than 24mm having a Nd:YAG capsulotomy were not likely to have a RRD.

v) History of Retinal Pathology.

A few patients in this series had, prior to cataract surgery, a history of retinal re-attachment surgery. Eleven eyes had RRD surgery in their presenting eye and 2 of these eyes detached. (P=0.10) In addition, 4 fellow eyes had a history of RRD. One patient in the latter group subsequently developed a RRD in the eye undergoing cataract surgery. (P= 0.046) While the numbers are small, the P-values are statistically significant for both groups of patients highlighting the potential for these eyes being at risk for the development of a RRD.
7.6 Discussion.

i) Association of Cataract Surgery and Retinal Detachment.

The risk of RRD following phaco-emulsification is not well defined. Previous studies have been hampered by results from a single surgeon, limited follow-up period and an inability to capture all patients developing RRD. Furthermore, it is not clear in some series whether the eye developing RRD was the eye that had undergone cataract surgery or what surgical technique was used to remove the cataractous lens. In spite of these limitations, estimates of risk have been formulated suggesting cataract surgery is responsible for 94% of the RRD occurring within the first year of surgery or alternatively the cumulative probability of developing a RRD is 5.5 times greater than expected for a comparison group not undergoing cataract surgery.

We have previously documented an ability to capture 98% of all patients presenting in the Auckland region using a surgical vitreo-retinal database as an end point. Furthermore, we have shown that 75% of patients developing a RRD following cataract surgery by any method present within 2 years of surgery and 90% within 10 years. In the current series the median interval between cataract surgery and the development of a RRD was 39 months. The duration of this latent period has been noted by other workers and highlights the importance of prolonged follow-up if accurate incidences of pseudo-phakic RRD are to be determined.

ii) Age as a risk factor of Pseudo-phakic Retinal Detachment.

The overall risk of developing a retinal detachment following cataract surgery by phaco-emulsification in our series was 1.16% but the risk was greater for males and those pseudo-phakic patients under the age of 50 years. The increased risk of RRD following phaco-emulsification in the under 50 age group has been previously documented. Wilkinson found...
6% of patients under the age of 50 years developed a RRD although the majority of these cases had a primary capsule discission and were all aphakic.\(^{(26)}\) Olsen et al noted in their series of 58 patients under the age of 60 years that those with axial lengths less than 24mm had a zero risk of RRD whereas 3 RRD occurred in 56 eyes with axial lengths 24mm or greater. In our series the increased risk of RRD in the younger patient was independent of axial length.

In our study we evaluated the risk of a history of retinal detachment. Whilst some statistical results were obtained, we believe the numbers in our series are too small to draw meaningful conclusions.

### iii) The significance of an intact capsule.

Chambless in 1985 reported on 3,047 consecutive cases undergoing extra-capsular cataract surgery utilising a Cavitron unit which enabled the nucleus to be removed by emulsification.\(^{(24)}\) In his series the rate of retinal detachment was 0.39%, with RRD occurring more frequently in eyes with open capsules, particularly where the vitreous was disturbed. Chambless also reported that 36% of the eyes studied required a post-operative capsulotomy, the majority of which were performed with a Ziegler knife.

The question of whether a Nd:YAG laser capsulotomy is associated with an increased risk of RRD remains controversial. Ambler et al retrospectively analysed 862 patients who had undergone Nd:YAG capsulotomy following ECCE surgery and determined a risk of 1.4%. Other authors have reported an incidence of RRD ranging from 0.08 to 3.6%.\(^{(33, 40)}\)\(^{(41, 42)}\)

Various factors are thought to influence the risk of RRD following Nd:YAG capsulotomy including length of follow-up, energy settings as well as presence of a posterior chamber IOL.\(^{(28, 40)}\)
Javitt et al studied 57,103 patients undergoing ECCE surgery and identified 13,709 eyes that subsequently required Nd:YAG capsulotomy. They found the risk of RRD in those eyes undergoing capsulotomy was nearly 4 times greater than in eyes with intact capsules. Whilst this study did not determine whether the eye that developed the RRD was the eye that had the capsulotomy, or indeed had undergone cataract surgery, the conclusion was that Nd:YAG capsulotomy was implicated in the pathogenesis of the detachment.

There is one report of a prospective study evaluating the risk of RRD and Nd:YAG capsulotomy rates associated with different cataract surgeries. The risk in that series was limited to those eyes having ECCE and no patient developed a RRD following a Nd:YAG capsulotomy who had had cataract surgery by phaco-emulsification. Indeed the only parameter found to be indicative of RRD in eyes having cataract surgery by phaco-emulsification was axial length.

Other recent reports evaluating the association of YAG capsulotomy and retinal detachment have shown either a slight or zero increase over eyes with intact posterior capsules. In our series, we did not find an increased risk of RRD in the 333 eyes undergoing YAG capsulotomy either for eyes with or without axial myopia.

iv) Axial myopia.

Axial myopia was a risk factor for RRD in the current series although not all eyes had readable axial lengths. Unfortunately, biometry recordings in the 1990s were typically printed on thermal paper and the legibility of the results of 531 eyes could not be read at the time of data analysis. We do not believe the lack of complete data has introduced a bias into the study as unreadable scans occurred with all surgeons and at varying time intervals. Those eyes with axial lengths greater than 24mm were more likely to develop RRD when matched for age and sex. Alldredge has also reported on 80 eyes with high myopia undergoing phaco-
emulsification including 64 eyes with axial lengths of 25.0mm.\textsuperscript{(31)} No patient in his series developed a RRD and the conclusion drawn was that modern cataract surgery was equally safe for high myopes. Similarly, Fan et al reported on 118 eyes undergoing cataract surgery with axial lengths greater than 26.0mm, 2 of whom developed RRD. \textsuperscript{(7)} In Fan's series a vigilant search was undertaken for retinal tears pre- and post-surgery and prophylactic laser treatment was applied when such a lesion was identified. Conversely, other groups have found prophylactic laser photocoagulation did not eliminate pseudo-phakic RRD in myopic patients.\textsuperscript{(45, 46)}

In our series, no prophylactic strategy was adopted and 2 eyes with axial lengths greater than 25mm developed RRD. Unfortunately, when the confounding factors of age and sex were taken into account, we concluded that our sample size was too small to draw any useful conclusions.

v) History of Retinal Pathology.

Fifteen eyes in our series had a history of retinal re-attachment surgery. Analysis of this subgroup revealed there was an increased risk of a subsequent retinal detachment but the risk was limited to the fellow eye. It is difficult to determine the significance of this finding due to the small numbers involved in our study. Other reports have conflicting results. Ruiz and Saati found only 1 retinal detachment occurred following extra-capsular surgery in 28 patients with a history of retinal re-attachment surgery.\textsuperscript{(47)} No recurrent retinal detachments occurred in a series of patients with a history of RRD who underwent cataract surgery by phacoemulsification \textsuperscript{(48)} although Grand determined in a similar population that the risk of developing a new retinal break or retinal detachment approximated 5\%. \textsuperscript{(49)} Our experience suggests that the risk of recurrent RRD is not zero but our data is too small to make meaningful comment.
In our series, 26% of the patients died in the 10 year follow-up period. These patients were censored from the date of death and treated as having attached retinas up until this date. Many reports have ignored the effect of death leading to perhaps erroneous conclusions that surgery is safer in the certain groups.\textsuperscript{(31, 34)} In the current series the mortality was higher in the aged but the risk of RRD in the elderly was lower even when corrected for the higher death rates.

7.7 Conclusion.

The risk of RRD following modern cataract surgery is relatively low even if the surgery is complicated by post capsule rupture or a post-operative Nd:YAG capsulotomy becomes necessary. However, the incidence of RRD is adversely impacted by the presence of axial myopia and the presence of a pre-senile cataract.
Chapter 7

Section II

7.8 References.


Chapter 8: Anatomical and Functional Outcome of Eyes undergoing Retinal Re-attachment Surgery.

8.0 Summary.

Background: Modern retinal re-attachment surgery is based on identifying retinal breaks, closing the breaks and removing any tractional element on the detached retina.

Objectives: To determine the anatomical and visual outcome of patients undergoing retinal re-attachment surgery.

Methods: One hundred and forty six patients undergoing retinal re-attachment surgery were evaluated prospectively for anatomical success and functional outcome.

Results: The overall success rate for retinal re-attachment was 94% with 72% being re-attached with one procedure. However, the re-attachment rate was worse for those eyes with a history of ocular trauma and who had previous retinal surgery. Patients presenting with macula-on RRD had a good anatomical and functional prognosis.
8.1 Introduction.

The surgical techniques favoured by contemporary retinal surgeons in retinal re-attachment surgery include pneumatic retinopexy, scleral buckling or vitrectomy.\(^{(1-3)}\) All of these approaches have strong advocates and the indications overlap as do the reported range of anatomical success.\(^{(4-6)}\) The functional outcome, however, is not thought to be related to the surgical technique except in terms of intra- or post-operative complications and re-attachment rate.\(^{(7,8)}\) Furthermore, the timing of surgery only appears important for macula-on detachments and for those eyes where the macula is already detached, elective surgery within a window of 10 days does not adversely affect outcome.\(^{(9)}\) However, there is some evidence to suggest that for macula-off detachments a surgical technique which ensures early foveal re-attachment is associated with a better functional outcome.\(^{(10)}\)

8.2 Methods.

The protocol for this study was approved by the Ethics Committee at our facility and conformed to the provisions of the Declaration of Helsinki.

The prospective study previously reported detailing 141 consecutive patients presenting with a RRD were re-examined to evaluate anatomical and functional outcomes following surgery.\(^{(11)}\) Five patients presented with bilateral RRD enabling 146 eyes to be included in the study. However, 15 eyes were subsequently excluded because of premature death, where primary surgical repair was not undertaken, or when repeat surgery was declined. One patient with bilateral retinal detachments but impaired intellectual ability was excluded on the basis of not being able to document visual acuity.

The patient demographics and previous ocular history as well as details of the ophthalmic findings were recorded on a standardised data sheet. Post-operative findings were collated
from the patient's medical file, and from the ophthalmologist initiating the primary referral. The anatomical end-point was determined at least 12 months after the final surgery.

The best corrected visual acuity was recorded immediately before surgery and again at one month, three months, and 1 year following the primary surgery. The post-operative interval was not reset for eyes requiring repeat surgeries. If the acuity was not recorded at the prescribed time, the acuity documented at the next closest assessment was recorded, provided this did not exceed a window equating to half that prescribed period. In the case of the 1 month recording this equated to 2 to 6 weeks, for the 3 month recording 6 to 18 weeks, and for the 12 month recording, 6 to 18 months. Visual acuities were converted from Snellen acuity to the logarithm of the minimum angle of resolution (LogMAR) for statistical analysis. For those eyes with significant visual loss (<5/200) the following LogMAR values were assigned - Count Fingers (CF) acuity equated to LogMAR 1.7, Hand Movements (HM) acuity became LogMAR 2, and Perception of Light (PL) LogMAR 2.3. No Perception of Light (NPL) equaled LogMAR 3. No patient underwent cataract surgery during the period under review.

**Statistical analysis**

Statistical analyses were performed in conjunction with a professional biomedical statistician. All values were entered into a Microsoft Excel database and subsequently imported into statistical software for analysis. Statistical analysis was performed in SPSS Version 12 for Windows (Chicago, IL, USA). Basic descriptive statistics were calculated on all data gathered and are reported as mean ± standard deviation or n (%) as appropriate. Likelihood ratio chi-squared tests and Fisher's exact tests were applied, as appropriate for testing associations between categorical variables. Correlations between continuous variables were examined by
calculating either Pearson's or Spearman's correlation coefficient (r). All tests were two-tailed and a p value of less than or equal to 0.05 was considered statistically significant.

### 8.3 Results.

There were 131 eyes from 129 patients eligible for this study. The mean age of the patients presenting in this review was 54.4 years with a standard deviation of 19.2 years. There were 76 men and 53 women. Forty eight of the eyes (34%) were pseudo-phakic at the time of the initial retinal re-attachment surgery and of the phakic eyes, 18 had a history of trauma. Ocular trauma was implicated as the initiating factor in 5 eyes in the pseudo-phakic group.

The anatomical result was determined in all cases but the post-operative acuity was unavailable in 7 eyes (5%). The demographic and ophthalmic findings of the patients with and without available post-operative acuities were deemed sufficiently similar to enable the latter group to be excluded without compromising the integrity of the data relating to the functional outcome. (Table 8-1)

**Table 8-1: The demographic and ophthalmic features of patients with and without post-operative acuities.**

<table>
<thead>
<tr>
<th></th>
<th>Cohort with known post-operative acuity. N=129 pts</th>
<th>Cohort without known post-operative acuity. N=7pts</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age</td>
<td>54.4</td>
<td>57.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Std Deviation</td>
<td>19.2</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>% pseudo-phakic</td>
<td>48/129 (37%)</td>
<td>3/7 (43%)</td>
<td>0.8</td>
</tr>
<tr>
<td>Male</td>
<td>76/129 (59%)</td>
<td>6/7 (85%)</td>
<td>0.10</td>
</tr>
<tr>
<td>Left sided RRD</td>
<td>57/129 (44%)</td>
<td>4/7 (57%)</td>
<td>0.50</td>
</tr>
</tbody>
</table>

The primary surgical procedures included pneumatic retinopexy in 21 eyes, conventional scleral buckling in 43 eyes and a closed intra-ocular micro-surgical approach was utilised in
65 eyes. (Table 8-2) Two retinal detachments were managed successfully by treatment using either cryotherapy or laser alone to limit the retinal detachment.

Table 8-2: Primary surgical procedure utilised on phakic and pseudo-phakic eyes.

<table>
<thead>
<tr>
<th></th>
<th>Limited Tx (Cryotherapy or laser)</th>
<th>Pneumatic Retinopexy</th>
<th>Scleral Buckling</th>
<th>Vitrectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudo-phakic Eyes (n=48)</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>Phakic Eyes (n=83)</td>
<td>2</td>
<td>17</td>
<td>27</td>
<td>37</td>
</tr>
</tbody>
</table>

Seventeen eyes (80%) having pneumatic retinopexy were phakic at the time of surgery whereas scleral buckling was used on 27 (63%) phakic eyes. A vitrectomy was the method of choice for 37 (57%) phakic eyes.

The overall success rate for retinal re-attachment was 94% with 72% being re-attached with one procedure. There were 36 eyes that had required repeat surgeries; the majority being successfully re-attached with two procedures. (Table 8-3)

Table 8-3: Number of surgical procedures performed to re-attach the retinae.

<table>
<thead>
<tr>
<th>Number of surgeries</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>95</td>
</tr>
<tr>
<td>Two</td>
<td>27</td>
</tr>
<tr>
<td>Three</td>
<td>8</td>
</tr>
<tr>
<td>Four</td>
<td>0</td>
</tr>
<tr>
<td>Five</td>
<td>1</td>
</tr>
</tbody>
</table>
Seven of the 21 (33%) eyes having pneumatic retinopexy required further surgery. Three of the eyes treated with pneumatic retinopexy developed new inferior breaks whereas the remaining 4 eyes were deemed to have failed because of inadequate retinopexy. Two of the 4 eyes with inadequate retinopexy had more than one break and were macula-off at presentation.

There were 4 pseudo-phakic eyes treated by pneumatic retinopexy, 3 of which required repeat intervention. The anatomical outcome for phakic eyes treated with the same technique was better but with marginal significance. \( p = 0.06 \)

Eight eyes (18%) treated with scleral buckling required repeat surgeries and in most (6/8) underwent a vitrectomy. Sixteen of the eyes undergoing scleral buckling were pseudo-phakic and only 2 (12.5%) failed. Anatomical success was less certain in phakic eyes but this was not statistically significant. \( p = 0.4 \)

Twenty one eyes experienced primary failure with a vitrectomy and of these 6 were pseudo-phakic. Nearly half the phakic eyes undergoing vitrectomy surgery for RRD required further intervention and as a group had the worse anatomical outcome. \( p = 0.0003 \)

An additional vitrectomy was performed on those vitrectomised eyes having repeat surgery, together with either placement or manipulation of a scleral explant. Typically a long-acting gas or silicone oil was used for tamponade in eyes requiring repeat surgeries.

Silicone oil was used in 24 of the primary surgeries and 21 of the repeat surgeries. During the follow-up period the silicone oil was removed in 30 eyes, 4 of which re-detached requiring further surgery.

In this series the retinae were successfully re-attached with one procedure in 95 eyes (72%). Ultimately 123 eyes (94%) achieved retinal re-attachment and in terms of outcome there was no statistically significant difference between phakic and pseudo-phakic eyes for either the primary procedure \( p = 0.4 \) or secondary procedures \( p = 0.9 \) Furthermore, the status of the
macula at presentation did not provide an indicator as to likely anatomical outcome. (p= 0.2).
The macula was attached in 53 eyes and of these 40 eyes (75%) were successfully re-attached
with a single procedure. Fifty five (70%) of 78 eyes with macula-off detachments were also
successfully treated with just one surgery.
The anatomical outcome however was worse for eyes with a history of trauma. The mean
number of surgeries was greater in previously traumatised eyes (p< 0.0001) as was the
proportion of eyes requiring repeat surgeries, (p< 0.0001) The anatomical outcome following
trauma was similar for both phakic and pseudo-phakic eyes. (p=0.14)
Visual acuity data was available on 95% (N=124) of the eyes at the 3 nominated follow-up
periods. Following retinal re-attachment surgery, 109 eyes either maintained or improved on
the presenting acuity although 15 eyes worsened with surgery. Two eyes lost perception of
light while another 3 eyes required enucleation during follow-up period. All of the eyes
requiring enucleation presented with chronic RRD and were macula-off. Two of the 3 eyes in
this sub-group had intra-ocular pressures of less than 10mm at presentation.
The visual outcome for macula-on detachments was generally favorable and 12 months after
the retinal re-attachment surgery 32 eyes (68%) achieved LogMAR 0.3 or better. (Table 8-4)
However 4 eyes with macula-on detachments, presenting with LogMAR 0.3 or better,
suffered a reduction in vision during the year long follow-up. Two of these eyes re-detached
and required further surgery and another 2 eyes developed lens opacities which lead to a
reduction in acuity. One of the eyes with a lens opacity also developed an epi-retinal
membrane.

Table 8-4: The functional outcome in eyes with and without a macula detachment 12
months following retinal re-attachment surgery.

<table>
<thead>
<tr>
<th></th>
<th>Macula-on (N=51)</th>
<th>Macula-off (N=73)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>124 eyes</td>
<td>32 achieved LogMAR 0.3</td>
<td>20 achieved LogMAR 0.3</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
The functional outcome was worse in macula-off retinal detachments, and only 27% of the eyes realised LogMAR 0.3 during the follow-up period. Furthermore, only 4 of 22 eyes requiring 2 or more retinal re-attachment procedures, presenting with a macula-off RRD regained LogMAR 0.3. However, with the exception of macula-off RRDs, the functional prognosis was not related to the number of procedures needed to re-attach the retina, although the presence of an outlier with a good visual outcome did negate the trend. ($r=0.3$, $p=0.6$)

Table 8-5: The visual outcomes (LogMAR 0.3 or better) related to number of procedures.

<table>
<thead>
<tr>
<th>Number of procedures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of eyes</td>
<td>N = 92</td>
<td>N = 23</td>
<td>N = 8</td>
<td>N = 0</td>
<td>N = 1</td>
</tr>
<tr>
<td>Number of eyes</td>
<td>43</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Total procedures = 124

Although there was no statistically significant difference in primary anatomical result with respect to phakic and pseudo-phakic eyes ($p=0.5$), the latter group overall had a less favourable functional outcome. (Figure 8-1) However the difference in functional outcome between phakic and pseudo-phakic eyes was only observed with macula-on detachments ($p=0.0003$).
There was no statistical difference in macula-off detachment in terms of the proportion of eyes achieving LogMAR 0.3. $(p=0.13)$

Eyes successfully treated by pneumatic retinopexy and scleral buckling typically recorded a stable acuity one month after surgery. Conversely, eyes treated by vitrectomy continued to improve over the first 3 months by which time the acuity for macula-on detachments was usually maximal. Thirty eyes presenting with macula-off retinal detachments experienced gains in visual function after the 3 month visit. The visual angle had doubled in 18 of these eyes by the 12 month post-operative visit.
8.4 Discussion.

In this series, a variety of surgical techniques were used by different surgeons to re-attach the retinas. The overall anatomical success rate approximated that reported in other series and confirms that most detached retinas are re-attached with one procedure. \(^{12-15}\)

The anatomical outcome for pseudo-phakic retinal detachments did not differ greatly from those eyes that were phakic. This contrasts with other reports that documented worse outcomes in pseudo-phakic eyes.\(^{16-19}\) In part, some of the difficulties ascribed to the repair of pseudo-phakic RRD relate to the difficulty in visualising the ocular fundus both pre- and intra-operatively. \(^{19,20}\) This in turn may be related to the method of cataract surgery as well as choice of intra-ocular lens.\(^{15,21}\) In the current series, the lack of a differential in terms of final anatomical outcome between phakic and pseudo-phakic eyes is more likely to be influenced by the history of ocular trauma which was more prevalent in the phakic eyes. Certainly those eyes with a history of trauma underwent more repeat surgeries and generally had a less favourable result. We did not find any association between the status of the macula and final anatomical outcome, but as expected those patients presenting with macula-on retinal detachments did achieve better visual results. Approximately 2/3 of the patients with macula-on detachments ultimately recorded Log MAR 0.3. We also noted in this series the visual outcome for macula-on detachments was influenced by the presence of a crystalline lens. A greater proportion of phakic eyes achieved LogMAR 0.3 than did the pseudo-phakic eyes. In the absence of any other risk factor, this result suggests that at least for the first 12 months following retinal detachment surgery, cataract development is not clinically relevant for the phakic patient.

The majority of patients presenting with macula-off retinal detachments did experience an improvement in visual functioning following surgery and in about half the eyes the angle of resolution doubled between 3 and 12 months. The progressive improvement in central acuity
following successful re-attachment of macula-off retinal detachments has been noted in other groups. Some of the improvement in function has been attributed to recovery of cone photopigment and this has been correlated with foveal densitometry. Wolfensberger has also found on serial OCTs that delayed resorption of sub-retinal fluid can occur at the macula for up to 12 months following retinal re-attachment surgery and, improvements in visual function correlate with resorption of that fluid. In another study, Kusaka et al reported on 32 macula-off retinal detachments and found that in some eyes the level of visual function could continue to improve for up to 5 years following surgery. Approximately half of the eyes in that study showed long-term improvement and this improvement correlated with those patients of a younger age, zero or low myopia and shorter duration of macula detachment.

In our series, we did not explore those factors that may have influenced the functional outcome for macula-off retinal detachments except to note that those eyes requiring more than one surgery fared worse than those eyes whose retinae were successfully re-attached with one procedure. This observation, while not validated for macula-on retinal detachments, should not detract from the goal of achieving primary re-attachment for all patients.
8.5 References.


Chapter 9: Familial Patterns of Rhegmatogenous Retinal Detachment.

9.0 Summary.

**Background:** There are a number of ocular and systemic syndromes that are associated with an increased risk of RRD. Many of these syndromes have a familial or genetic basis but it is equally appreciated that some RRD may occur in families without any associated systemic or ocular abnormalities.

**Objective:** To report a small New Zealand pedigree presenting with a familial pattern of non-syndromic RRD. The difficulties of determining a genetic locus for non-syndromic RRD will be outlined together with a review of the approaches that may be ultimately useful for such patients.
9.1 Introduction.

Most RRD are considered sporadic, occurring when a set of largely unknown events set the stage for the development of a retinal break and resultant RRD.\(^{(1-3)}\) Some of the risk factors for RRD are recognised, and include male sex, increasing age, myopia, intra-ocular surgery and trauma.\(^{(4-7)}\) The precipitating event in the presence of such risk factors can culminate in those events leading to that final common pathway, namely vitreous traction, with subsequent development of a retinal break and accumulation of sub-retinal fluid, clinically described as a retinal detachment.\(^{(8)}\) While some of these precipitants are clearly environmental, there are grounds for suggesting that at least some retinal detachments are inherited or are at least familial.\(^{(9, 10)}\) The family which is the subject of this report highlights the limitations and difficulties of evaluating a small family pedigree in a disorder which can be precipitated by a number of different aetiologies and can be genetically heterogeneous.

9.2 Procedure and Methods.

The male proband (II-3) (Figure 9-1), aged 65 years, presented with a blind right eye secondary to a long-standing RRD and a recent history of visual loss in the left eye. There was no known medical history of note and on enquiry no symptoms of a musculo-skeletal nature were reported. A detailed medical examination was performed and while no systemic abnormality was found he was noted to have a mild pectus excavatum. The proband did not have any cardiac disease and there was no sensori-neural hearing loss. Examination of the left eye revealed a RRD secondary to a giant retinal tear which exceeded 6 clock hours. The surgical approach included a 20-gauge 3 port vitrectomy, and oil was used to tamponade the retina. The oil was ultimately removed but the visual outcome was limited due to persisting macular oedema. While under active review, the proband’s daughter (III-4), aged 39 years, presented with a RRD secondary to giant retinal tear in her left eye. Her medical examination
was normal and the only other ophthalmic finding of note was her myopia. (OD -4.25 DS, OS - 3.75DS). The vitreous did not have any fibrillar change and no membranes were noted in the anterior vitreous. Three months after the initial repair the patient re-presented with a RRD secondary to a GRT in her fellow eye. At this stage a formal family pedigree was recorded and it was determined that the proband's sister (II-2) at age 57 years had developed a retinal detachment which was treated in Cambridge, England. Subsequent enquiry revealed her pathology was unilateral, with 7 horse shoe tears precipitating a RRD in her right eye. The only other family history of note was that the proband's father (I-1) was said to have died of a collapsed aorta at the age of 47 years.

Figure 9-1: Family pedigree with autosomal dominant pattern of rhegmatogenous retinal detachment.
i) Family and DNA Specimens.

The New Zealand family was of English extraction and included 12 individuals, 2 of whom were affected with bilateral RRD. The individual designated II-2 had a unilateral RRD successfully repaired in the UK and has not had further problems. The 12 family members ranged in age from 5 to 65 years and underwent a comprehensive ophthalmic examination and, where indicated, this was augmented by a medical examination. The study was approved by the Ethics Committee at our institution; and informed consent was gained from all family members except those minors where parental consent was obtained. Blood was obtained from II-3 and IJI-4 for isolation of genomic DNA and sent to the Department of Clinical and Human Genetics, VU University Medical Center, Amsterdam, The Netherlands for FBN1 analysis. A second sample was also sent to Matrix DNA Diagnostics, Tulane University Health Sciences Center in Louisiana for COL2Al and COL11Al analysis.

ii) Candidate Gene Analysis.

The DNA was extracted from a peripheral blood sample using the PureGene whole blood kit (Gentra Systems Inc, Minneapolis, MN, USA) which is based on a modified salt-precipitation method.

Initially a search was conducted on the FBN1 (fibrillin) locus 15q21.1 and all 65 exons of the FBN1 gene, including the adjacent parts of introns, were screened for mutations. Large deletions and duplications were tested by multiplex ligation-dependent probe amplification (MLPA kit P066 v3). The analysis of the FBN1 gene was performed by denaturing high performance liquid chromatography (DHPLC) using the WAVE system, followed by direct DNA sequencing of aberrant products with aberrant wave appearance.

Sequencing of the collagen genes COL2Al and COL11Al was also performed and both exons and portions of the flanking non-coding regions were amplified by the PCR method. The
individual amplicons were then screened for the presence of heteroduplexes and then directly sequenced to reveal DNA alterations. Primers and conditions are available on request.

9.3 Results.

No mutations were found on either the *FBN1*, *COL2A1* or *COL11A1* genes. In the 6 asymptomatic family members no ophthalmic abnormality was noted. The demographic data as well as ophthalmic and relevant systemic findings are recorded in Table 9-1. An echocardiogram was performed on two family members (II-3, III-4) while awaiting the results of the genetic studies and both were reported as normal, with good ventricular systolic function and no evidence of any aortic root dilation or aortic regurgitation.

Table 9-1: Demographic, ophthalmic and systemic findings in study family.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age at time of study</th>
<th>RRD present</th>
<th>Refraction</th>
<th>Systemic findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>II-2</td>
<td>63</td>
<td>Yes</td>
<td>Emmetropic</td>
<td>Nil</td>
</tr>
<tr>
<td>II-3</td>
<td>65</td>
<td>Yes</td>
<td>Emmetropic</td>
<td>Normal echo</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pectus excavatum</td>
</tr>
<tr>
<td>II-5</td>
<td>Not examined</td>
<td></td>
<td>Emmetropic</td>
<td></td>
</tr>
<tr>
<td>III-1</td>
<td>Not examined</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III-2</td>
<td>Not examined</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III-3</td>
<td>40</td>
<td></td>
<td>Low myope</td>
<td>Normal echo</td>
</tr>
<tr>
<td>III-4</td>
<td>39</td>
<td>Yes</td>
<td>High myope</td>
<td></td>
</tr>
<tr>
<td>III-6</td>
<td>32</td>
<td></td>
<td>Hyperopic</td>
<td></td>
</tr>
<tr>
<td>IV-1</td>
<td>9</td>
<td></td>
<td>Emmetropic</td>
<td></td>
</tr>
<tr>
<td>IV-2</td>
<td>5</td>
<td></td>
<td>Emmetropic</td>
<td></td>
</tr>
</tbody>
</table>
9.4 Discussion.

Although we did not find any genetic mutation in the 3 genes tested, it does seem likely that *this family* does have either an underlying genetic defect or genetic predisposition to RRD in view of the strong dominant behaviour observed *in this pedigree*. The probability of five RRD occurring in this family as the result of a random event secondary to external environmental or lifestyle influences is remote. In the family under review, the presence of pectus excavatum in the proband plus the suggestion that a previous *family member* had died at an early age of cardiac disease prompted a thorough cardiac review including echo-cardiography. *Simultaneously*, a search at the *FBN1* locus was undertaken to exclude the possibility that this family had Marfan syndrome. While not all *patients* with Marfan syndrome have abnormalities at this locus, it is estimated that >95% do.\(^{(11)}\) The parallel search for mutations at the *COL2A1* and *COL11A1* loci was justified by the possibility that this family may have Stickler syndrome, albeit with a seemingly normal physiogemy.\(^{(12,15)}\) We have previously determined that the risk for any given individual to develop a RRD is small.\(^{(16)}\) Indeed, while *that risk is age related*, the chance of a female in the 4th decade of developing a RRD in New Zealand is 5.8 per 100,000 per year. Similarly, the *risk for the proband* is calculated to be 55.3 per 100,000 per year. We do not have comparative data for the family member in the UK but if the *risk is similar* to the data in New Zealand then the risk of II-2 developing a RRD would be 15.8 per 100,000 per year. The aggregative risk therefore for *this family* would equate to 1 in 10.\(^{(11)}\)

Many surveys of patients presenting with RRD ignore the importance of family history and hence the true incidence of familial RRD is likely to be under-represented in the literature. Indeed, unless a careful family history is taken, evidence suggests the proband is likely not to recall or be aware of affected relatives.\(^{(17)}\) One study that recently investigated the incidence of familial RRD was reported by Go et al.\(^{(18)}\) This group *investigated* 203 consecutive
patients presenting with RRD and determined that for first degree relatives, the risk was 3 times greater than for the control population. The risk was significant for siblings of patients presenting with retinal detachments but not for their offspring. Other investigators have also reported an increased risk of retinal detachments in relatives of patients with RRD but such reports are sparing.\textsuperscript{(19, 20)} This contrasts with those pedigrees with a familial pattern of RRD but that are associated with systemic or ocular syndromes such as Von Hippel Lindau, Familial Exudative Vitreo-retinopathy, or Stickler syndrome. Indeed the difficulty in identifying a familial or genetic link for patients presenting with RRD without a recognised syndrome relies almost exclusively on a detailed family history. Certain features may however suggest a familial or genetic link such as age of patient at presentation, bilateral involvement, as well as a history of myopia.\textsuperscript{(20-22)} Some sub-types of RRD are also recognised to have a genetic basis and include retinal dialyses, giant retinal tears, and retinal breaks associated with peripheral retinal degenerations such as snowflake dystrophy.\textsuperscript{(21)} \textsuperscript{(23, 24)} Conversely, most patients presenting with these findings are thought to be sporadic in origin.\textsuperscript{(25)}

The importance of racial variation on the incidence of RRD has also been highlighted recently and confounds the impact of familial and genetic analysis. Wong et al reviewed the ethnic background of patients presenting with RRD in Singapore and found the rate of RRD was approximately three times greater for Singaporeans of Chinese background as compared to those belonging to the Indian community.\textsuperscript{(26)}

The predominant ethnic group in Taiwan are also Chinese, and Chou et al found a correlation between RRD in younger patients and high myopia (> or equal 6D).\textsuperscript{(4)} The association of RRD and high myopia is well recognised but the risk for younger patients has not been previously highlighted. Furthermore, the group of patients described by Chou et al, aged 20-30 years, developed RRD secondary to round holes.\textsuperscript{(4)} Indeed in that population there was a
bimodal distribution of RRD with a second peak occurring in patients aged 50-54 years. Other Asian countries have also noted a bimodal distribution of RRD with respect to age and the high prevalence of myopia in Asia appears likely to account for this difference. (7, 27, 28)

The prevalence and severity of myopia has increased markedly in a number of Asian countries over the last few decades and this trend has also been identified, although to a lesser extent, in both Europe and Australia. (29-31) A nationwide survey of school children in Taiwan conducted in 1988 and repeated in 2000 showed a 10-20% increase in myopia for all age groups with the mean refractive error increasing by 1.0D for children aged 15 years. (32) A shift of this magnitude in such a short time frame suggests the change is secondary to environmental or behavioral influences, although it is widely accepted that a genetic basis for both low and high myopia can occur. (29) The impact of increasing myopia on the genesis of RRD is likely to lead to more cases of retinal detachment and in younger individuals. (4)

Two peripheral retinal lesions, namely snowflake dystrophy and lattice degeneration, are also associated with an increased risk of RRD and can exist as isolated findings in otherwise normal eyes. (33, 34)

Snowflake degeneration is an autosomal dominant vitreo-retinopathy that was originally described by Hirose et al and has recently been reviewed. (35) The risk of RRD in patients with snowflake degeneration is reported to approximate 25% and whilst the genetic abnormality is not known, it is believed to result from a locus distinct from other vitreo-retinopathies. Linkage studies in families with an autosomal dominant disease pattern suggest the 9Mb region on chromosome 2q36 is the site of the abnormal gene. (24) Snowflake degeneration is not thought to have any systemic associations, although some members of the pedigree can have other ocular findings which may be indicative. These include early onset cataract, low myopia, optic nerve head dysmorphism and a fibrillar vitreous. In one pedigree the presence
of floaters was almost universal. Many of these findings occur however in otherwise normal individuals who do not appear to be at increased risk of RRD. The association of lattice degeneration and RRD has been appreciated for many years and cross-sectional studies report lattice degeneration is found in approximately 30% of eyes with RRD. In most cases lattice degeneration is not thought to be familial but certain subtypes of lattice degeneration may have a hereditary basis especially when associated with other peripheral hereditary degenerations such as Stickler syndrome. Murakami-Nagasako and Ohba have reported on a cohort of patients with isolated lattice degeneration and found the prevalence of lattice in first degree relatives was 23%. In the control population the prevalence of lattice was 8%. This group did not find any statistically significant difference between first degree relatives, with parents, siblings and children having a similar degree of involvement. The inheritance pattern did not fit a monogenic mode of inheritance and it was concluded that a polygenic or multi-factorial mode of inheritance was most likely for this population.

In contrast to these few clinical findings associated with RRD in apparently normal or non-syndromic eyes, there are a number of systemic and ophthalmic syndromes with a familial or genetic basis that have an increased risk of RRD. Some of the best understood are associated with connective tissue disorders and a feature of most is both an intra- and inter-familial variation in expressivity of disease. The importance of this observation is that affected individuals may not demonstrate those typical manifestations normally associated with that syndrome, and that many of the signs noted in one syndrome may also be found in other syndromes. An example of an inherited vitreo-retinal syndrome with both wide intra- and inter-familial variation is Stickler syndrome. Stickler syndrome is the most common inherited vitreo-retinal syndrome associated with RRD and was originally reported in 1965. The original description was based on 11 individuals covering 5 generations. The
inheritance pattern was noted to be autosomal dominant and affected individual's demonstrated congenital and progressive high myopia with early onset retinal detachment. Extra-ocular manifestations included a progressive arthropathy often associated with joint hypermobility, and in some family members, sensori-neural deafness. Many family members also demonstrated a midface hypoplasia and other midline abnormalities. (43)

A similar hereditary arthro-ophthalmopathy with autosomal dominant inheritance had already been described by Wagner in 1938. (44) That report described a family with low myopia (<3.0D), abnormal vitreous bands, and juvenile onset lens opacities. A subsequent review of the original family highlighted peripheral vascular sheathing, chorio-retinal atrophy and peripheral retinal degeneration and an increased risk of RRD. (45) More recently, anterior segment dysgenesis has been identified in affected family members. (46)

Subsequent to these reports, additional pedigrees have been described with apparently similar systemic and ophthalmic signs thought to be indistinguishable from Stickler and Wagner syndromes. (47-49) This, together with the wide phenotypic variation within many pedigrees, has added to the confusion and lead some authorities to conclude they were one and the same syndrome. (50-52) Recently however, parallel studies in molecular biology and in particular collagen biosynthesis have enabled a number of the syndromes to be differentiated and more clearly understood. For example, it is now recognised that the majority of patients with Stickler syndrome (Type I families) result from mutations at the COL2AL locus which is located on chromosome 12. (40) This gene comprises 54 exons and codes for the precursor type II collagen, an essential component of human vitreous. ("COL2AL" refers to a gene that encodes for type II collagen, the alpha-1 chain.) The majority of patients with Type I Stickler syndrome have mutations resulting from incorporation of a premature termination codon, either by frameshift, mis-splicing or point mutations. (53) These changes typically result in a
phenotype that is largely restricted to ocular signs with an anterior vitreous having a membranous appearance while the posterior vitreous appears optically empty.\(^{(54)}\) Approximately one-third of families with Stickler syndrome have a Type II variant with predominantly mis-sense mutations in either the \textit{COL11A1} or \textit{COL11A2} genes.\(^{(55, 56)}\) Both \textit{COL11A1} or \textit{COL11A2} genes code for chains associated with collagen X1 production namely \(\alpha1(\text{X1})\) and \(\alpha2(\text{X1})\) respectively.\(^{(55)}\) Only individuals with mutations in \textit{COL11A1} are at risk of ocular involvement as \(\alpha2(\text{X1})\) chains are not expressed in human vitreous.\(^{(57)}\) Patients with Type II Stickler syndrome typically share a similar systemic phenotype with skeletal, joint involvement and mid-facial abnormalities.\(^{(10)}\) Typically, the vitreous in affected individuals has a beaded or fibrillar appearance which is believed to reflect the underlying inability of the abnormal \(\alpha1(\text{X1})\) chains to regulate the diameter of the Collagen II fibrils.\(^{(58)}\) The recognition that certain pedigrees with autosomal dominant RRD could have predominantly ocular manifestations in the presence of mutations governing collagen synthesis or assembly prompted us to explore this family for mutations in \textit{COL2A1} and \textit{COL11A1}. While this search, as well as that at the \textit{FBN1} locus, was negative there have been recent descriptions of families with autosomal dominant \textit{RRD} and mutations in the \textit{COL2A1} that are not linked with Stickler syndrome.\(^{(14, 15)}\) One family demonstrated a novel mutation at \textit{COL2A1} which lead to the substitution of the obligate glycine within the collagen helix to arginine.\(^{(15)}\) The impact of this amino acid substitution has been previously associated with a severe form of a type II collagenopathy\(^{(59)}\) but in the family reported no systemic abnormality was found and the ophthalmic findings were limited to RRD and retinal breaks. This suggests that the mutation may have also resulted in a premature termination codon leading to nonsense mediated decay of the mutant transcript or protein or alterations at the level of the intron-exon boundaries leading to activation of a silencer sequence.\(^{(13, 60, 61)}\) Another report describes an Arg453Ter mutation occurring at the \textit{COL2A1} locus where an
autosomal dominant pattern of RRD was found.\textsuperscript{(14)} Again in this family no other systemic or ocular abnormality was consistently found.

The implication from these two families is that non-syndromic RRD can be inherited in a clearly inherited autosomal dominant pattern and that while we did not demonstrate a genetic basis in the 3 candidate genes for the family under our care, it does mean that a family history should be part of the management for patients presenting with RRD.
9.5 References.


Section III: Conclusions
Chapter 10: Conclusions.

10.1 Goal of Thesis.

A goal of this thesis was to determine those factors involved in the pathogenesis of RRD and to provide a contemporary review of the literature for those lesions which might predispose to the development of RRD. I extended this brief by performing a year long, prospective study on a group of patients who developed a RRD. Using data from the NZ census I was able to determine that the overall incidence of RRD in the study area was 11 per 100,000 people. The incidence was found to be age-related and when the data was examined in age bands the rate of RRD was shown to progressively increase from 1.5 cases per 100,000 for those aged less than 10 years to a rate approaching 50 per 100,000 for individuals in the 7th decade of life. This age-related peak has also been noted in a number of other reports including large surveys from Europe and North America. However, recently a bi-modal distribution in the rate of RRD has been noted in some Asian populations, with an additional peak occurring in the 3rd decade. One group attributed the initial peak in rate of RRD to increases in prevalence and severity of myopia. If this relationship is confirmed, and the world trend of increasing myopia continues, greater numbers RRD should be expected.

A further finding from the epidemiology survey was that many patients present with the macula already detached. Since the status of the macula has prognostic implications, a parallel enquiry was conducted into identifying what symptoms might be important in establishing a diagnosis of RRD. Unfortunately the findings of this survey were not sufficiently specific or sensitive to provide a reliable indication of RRD. While this does not necessarily negate the usefulness of symptoms in contributing to the diagnosis of a RRD, it does suggests other factors such as age, sex, and intra-ocular history should be evaluated when an attempt is made to profile those patients at risk of a RRD. That study also confirmed some patients with RRD
were asymptomatic and that the absence of symptoms does not negate serious ocular pathology. Patients with a previous history of RRD either in their presenting or fellow eye were more likely to be asymptomatic than those patients without a history of retinal disease. Some patients with bilateral RRD were symptomatic in one eye yet asymptomatic in the fellow eye suggesting ocular parameters were important rather than the insight or intelligence of the patient.

Another finding of the original investigation was that approximately one-third of patients presenting with a RRD had undergone cataract surgery. This conclusion however was limited in that a variety of cataract techniques had been performed. However, the finding was of sufficient merit to encourage a retrospective review into patients having undergone cataract surgery by phaco-emulsification. This study revealed a sharp dichotomy of risk, in that patients under the age of 50 years had a high risk of RRD whereas the risk was significantly lower in the 70 and older group. Other sub-groups at greater risk of RRD included those patients with longer axial lengths and those who had cataract surgery complicated with vitreous loss. There were 332 patients in that study who required a Nd:YAG capsulotomy, but the rate of pseudo-phakic RRD in this group did not differ from those patients with an intact posterior capsule. While this is at variance with a number of other published reports\(^7\,8\) there are some groups who have also found Nd:YAG capsulotomy did not increase the risk of RRD.\(^9\,11\)

Two further reports have subsequently been published evaluating the risk of RRD following phaco-emulsification. One was a population-based study which showed that the cumulative probability of developing a RRD was 4.0 fold greater 20 years after cataract surgery than for phakic eyes.\(^12\) That group also noted the risk of RRD was greater in patients undergoing cataract surgery at a younger age. The Moorfields group also reported on the risk factors for RRD following cataract surgery by phaco-emulsification and determined from a case control
series that patient characteristics rather than surgical complications constitute the major risk factors. (10)

10.2 Sporadic and Familial RRD.

Not all patients developing RRD can be classified as either secondary to cataract surgery or simply idiopathic. The literature includes references to a number of inherited disorders which predispose individuals to the development of a RRD. (13, 14) A useful subdivision has been to record those individuals with a familial pattern of RRD as being associated with a syndrome either ocular and/or systemic, and the group where the RRD is an isolated finding, that is non-syndromic. Included in this thesis is a report of two family members who presented with bilateral and apparently non-syndromic retinal detachments. Further enquiry revealed that another family member in the UK had also undergone retinal re-attachment surgery and this led to a search for the abnormal genotype. Unfortunately the number of candidate sites known to be associated with non-syndromic RRD is few and in spite of a concerted investigation, we did not find evidence for concluding there was a genetic basis for the RRD in this family.

10.3 Treatment Options.

The series of studies as contained in this thesis did cause the author to wonder about the management of RRD in New Zealand over the recent decades and an interesting record of development and change was found in the now defunct proceedings of the Ophthalmic Society of New Zealand (OSNZ). I am especially grateful to those senior colleagues, past members of the OSNZ, who gave freely of their time to explain how and why certain treatment methods were championed during the evolution of the management of RRD repair in New Zealand.
As to the future, there is a continuing expectation that improvements can be made in both the early detection as well as the management of patients presenting with retinal detachments. There are a number of proponents advocating certain approaches to re-attach the retina but surprisingly few comparative studies have been reported. A lack of randomisation, small sample size, as well as multiple exclusion criteria, limits the relevance of these reports. Furthermore, most published reports are limited to reporting outcomes in terms of anatomical and functional success. Little is known about the relationship of quality of life indicators, economic burden to patient or payee, and surgical technique. The on-going multi-centre study sponsored by the European Vitreo-retinal group may provide better guidelines for surgical technique but ultimately developments in small gauge vitrectomy and wide angle viewing systems may supercede this group’s conclusions. The evidence for initiating prophylactic treatment to eyes at high risk of RRD is in the main deficiency and intervention has only been documented to be of benefit in a few clinical scenarios. Ultimately, further studies may identify a treatment advantage but it seems unlikely that isolated retinal lesions, with the exception of symptomatic retinal tears, will be sufficient to identify those eyes at high risk. At present, the consensus strategy to prevent visual loss from RRD is to support public health campaigns directed at individuals with symptoms of posterior vitreous detachment and encourage them to have a dilated retinal examination. Regrettably, the evidence that such campaigns are effective is minimal.

10.4 Future Perspectives.

As regards the potential for improvements in visual outcomes, there is an obvious need to assess those parameters which adversely effect retinal function during retinal detachment. A number of pre- and peri-operative findings have been shown to be important in determining final visual outcome including length of follow-up, age of patient, degree of myopia and co-
existing pathology.\textsuperscript{(25-27)} Similarly, the height of the detachment as well as the duration of a macula-off RRD can influence the final visual result.\textsuperscript{(28)} These findings are thought at least in part to be related to pathological changes seen in detached retinas both with light and electron microscopy.\textsuperscript{(29)} These changes are first noted in the outer retina but time-related changes also occur in the inner retina.\textsuperscript{(30)} Following separation of the outer segments and RPE cells there is a rapid change in the RPE apical processes, degeneration of the cone outer segments and a steady decline in the thickness of the outer nuclear layer indicating demise of the photoreceptor.\textsuperscript{(31-34)} In the inner retina there is a re-modeling of the horizontal and bipolar cells and in some cases a proliferation of Muller cells occurs.\textsuperscript{(35)}

The histological changes that are associated with detachment of the neuro-retina are mirrored by alterations in intra-cellular enzymes and proteins including cytokines, growth factors, as well as extra-cellular amino acid neurotransmitters.\textsuperscript{(36-38, 39)} Some of these responses are also seen with other retinal pathologies suggesting common pathways exist.\textsuperscript{(40)} During RRD, photoreceptor apoptosis typically occurs, although a differential exists between the rods and cones.\textsuperscript{(41)} Apoptosis is believed to result from hypoxic influences and the degree of hypoxia is largely determined by the height of the retinal detachment.\textsuperscript{(42)} This has been shown to have a clinical correlate in that the height of the detachment at presentation is related to the final visual outcome in macula-off RRD.\textsuperscript{(28)} Interestingly, supplementary oxygen has been shown, at least under experimental conditions, to substantially mitigate many of the adverse effects to the outer retina normally found with retinal detachments.\textsuperscript{(30)} The potential for hypoxia-inducing pathological changes in the inner retina would seem less likely in those animals with an intra-retinal circulation.\textsuperscript{(29)} However, supplementary oxygen was of benefit in the feline retina, which has a robust retinal circulation, so limiting the proliferation and reactivity of Muller cells which are associated with glial-based complications of retinal detachment, namely proliferative vitreo-retinopathy.\textsuperscript{(35)}
10.5 Clinical Tools to Investigate RRD.

Until recently, non-invasive clinical investigations of patients with RRD have been largely restricted to simple psychophysical and electrophysiological testing. Ultra-sound imaging was limited documenting the height and extent of the detachment although some information about the extent of PVR could also be inferred. Such tests complemented the laboratory investigations and provided direction into new areas of study. For example, a sustained improvement in the level of visual functioning suggested at least some capacity for repair existed in the retina. The evaluation of cone functioning by the electroretinogram revealed a differential exists between these photoreceptors in recovery following retinal re-attachment surgery.\(^{(43)}\)

The recent introduction of a high resolution OCT has enabled another modality to be utilised in the study RRD. This instrument can image in real time, cellular and extra-cellular changes that can occur during retinal detachment.\(^{(44, 45)}\) Software developments in OCT can quantify those changes and provide a method to evaluate those strategies which may limit or negate the adverse responses seen with RRD. The development of ultra-high resolution OCT with femtosecond solid-state lasers is likely to further enhance diagnostic ability and with axial resolution approaching 3\(\mu\)m the morphology of intra-retinal layers should be possible.\(^{(46)}\)

10.6 Therapies to Improve Visual Function Following RRD.

This work did not directly address treatment strategies which may improve visual functioning following retinal surgery but did note certain adverse events could compromise both anatomical and functional outcome. Repeat and failed surgeries were not unexpectedly associated with poor outcome. Similarly, patients presenting with hypotony fared worse. There were 30 patients in our series that underwent removal of silicone oil following successful re-attachment of the retina. No patient experienced the severe visual loss that has
been recently described in eyes with attached retina following silicone oil removal.\(^{(47, 48)}\)

However this complication does highlight the need for a greater understanding of the molecular and cellular changes accompanying retinal detachment and surgery.

We did not document the extent or height of the retinal detachment in the eyes undergoing surgery but the recent report demonstrating this parameter as having prognostic implications does suggest strategies influencing the extent of the detachment prior to surgery may play a beneficial role in visual rehabilitation.\(^{(28)}\) Similarly, the observation that vitrectomy induces foveal re-attachment at an earlier stage and does so more reliably than scleral buckling and leads to a better visual outcome is of great interest.\(^{(49)}\) While that finding does appear to be at variance with the PARD study which showed no discernable benefit between the two techniques for both pseudo-phakic and aphakic retinal detachments, it does highlight an area where future study might be directed.\(^{(17)}\)

While it seems likely that further refinements in surgical technique will evolve and produce better outcomes, the significant advances will emerge from the arena of neurobiology.\(^{(40)}\) The concepts of neuronal rescue and neuroprotection may ultimately have as much relevance for the retinal surgeon of tomorrow as the retinal tear was for Gonin. The goal therefore of future management of RRD may be less about restoring the anatomy and more about promoting visual function.
Chapter 10

Section III

10.7  References.


Section IV: Appendices
Appendix 1: Pre-operative Assessment Questionnaire

**Study Protocol**

<table>
<thead>
<tr>
<th>Study No.</th>
<th>Hospital/Clinic No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participating Dr.</td>
<td></td>
</tr>
</tbody>
</table>

### Patient Characteristics

- **Age:**
- **Date of Birth:**
- **Sex:**
- **Domicile In:**
- **Town/City:**
- **Medical History:**
- **Smoker:**
- **Diabetic:**
- **Hypertension:**
- **CORD:**

### Past Ophthalmic History

- **Presenting Eye:**
- **Fellow Eye:**
- **Ambylopia:**
- **Injury:**
- **Ha of Retinal Tear:**
- **Ha of Retinal detachment:**
- **Cataract Surgery in Presenting Eye:**
  - **YR**
  - **AC IOL/PC IOL/OTHER**
  - **YIT in AC/Complicated**
- **Yag Capulotomy**
  - **YR**

### Existing Ophthalmic Pathology

- **Presenting Eye:**
- **Fellow Eye:**
- **Myopia > 6D:**
- **PVD:**
- **Glaucoma:**
- **Ophthamic Medications**
- **Surgical Hx**
- **On pilocarpine (duration)**

### Presenting Symptoms

- **Asymptomatic**
- **Flashes**
- **Floaters**
- **Shadow**
- **Loss of Vision**
- **OTHER**

<table>
<thead>
<tr>
<th>Presenting Symptom</th>
<th>Y/N</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Study Protocol

**Ophthalmic Findings in Presenting Eye**

Eye Involved: ___________________________ R/L: ___________________________

Visual Acuity: ___________________________

IOP: ___________________________

Vitreous:

- Cells: Y/N
- Pigment: Y/N
- Blood: Y/N

Breaks:

1. ___________ 2. ___________ 3. ___________

- Location
- Extent (in clock hours)

Macula: On/Off

PVR:

- Macula
- Posterior
- Anterior

**Treatment**

*Not Operable/Declined Surgery*

1. Laser/Cryo alone
2. Pneumatic Retinopexy
3. Conventional Surgery

- Gas injection: □ YES □ NO
- Subretinal fluid drainage: □ YES □ NO
- Laser: □ YES □ NO
- Cryotherapy: □ YES □ NO

4. Vitrectomy

- Membrane peel: □ YES □ NO
- Scleral Expant: □ YES □ NO
- Gas injection: □ YES □ NO
- Oil injection: □ YES □ NO
Appendix 2: Publications Related to this Thesis.


Northern New Zealand Rhegmatogenous Retinal Detachment Study: epidemiology and risk factors

Philip J Polkinghorne FRCOphth and Jennifer P Craig PhD
Department of Ophthalmology, University of Auckland, Auckland, New Zealand

ABSTRACT

Background: The incidence of retinal detachment in New Zealand is not currently documented in the literature. This study sought to determine the annual incidence of rhegmatogenous retinal detachment (RRD) and associated risk factors in northern New Zealand.

Methods: Epidemiological and clinical data were collected for all patients presenting with a RRD in a 12-month interval in a confined geographical area of New Zealand.

Results: One hundred and forty-one patients presented between May 1997 and April 1998 with a RRD. Five patients presented with bilateral RRD. The mean age at presentation was 53.9 years and the annual incidence for RRD was 1.8 cases per 100 000 people. RRD was more common in males than in females (1.3:1). Ocular trauma, high myopia and cataract extraction were found to be significant risk factors in the development of RRD.

Conclusions: The annual incidence of RRD in northern New Zealand is comparable to values reported for other parts of the world and, consistent with previous studies, the incidence of RRD was found to increase with age, and in association with trauma, high myopia and cataract surgery.

Key words: incidence, New Zealand, retinal detachment.

INTRODUCTION

Rhegmatogenous retinal detachments (RRD) are an uncommon cause of ocular morbidity. In most parts of the developed world, patients presenting with retinal detachments are referred to those ophthalmologists with surgical retinal expertise. This approach, in a time of budgetary constraints, means resources and personnel must be matched with the need. Part of the matching process involves collection of epidemiological data and evaluating risk. Recent studies have noted a RRD incidence of 5-14 people per 100 000 per year.1-4 Similarly the prevalence has been studied and believed to range between 3 and 5 per 10 000.5,6

The major risk factors for developing a RRD include high myopia, ocular trauma, cataract surgery and increasing age.7-9 The Northern New Zealand Retinal Detachment Study evaluated in a prospective manner the incidence of RRD in a geographically limited region and explored various relationships that may be important.

METHODS

Northern New Zealand Retinal Detachment Study

The area of study covered the northern half of the North Island of New Zealand, home to 1.2 million people. Data were collected over a 12-month interval (June 1997 - May 1998) in a prospective fashion on all patients presenting with a RRD. This area of New Zealand is circumscribed geographically with the majority of the population living in a single urban area, Auckland. An adjacent city 200 km south of the study area with a surgical retinal facility screened all patients presenting to that service for any patients domicile in the study area. No such patients were identified. There were seven retinal specialists who participated in the study.

Inclusion criteria

A rhegmatogenous retinal detachment was defined as a break in the retina that allowed fluid vitreous to enter the subretinal space and extend for at least 2 disc diameters. Included in the study were patients with a history of trauma, previous retinal detachment and retinal tears. We did not exclude patients with previous intraocular surgery. Patients with combined traction RRD as seen in diabetes were included in the study. Similarly patients with localized subretinal fluid associated with macular holes were also excluded.

Patients presenting with a recurrent RRD within 4 months of any primary repair were considered to have
The New Zealand Department of Statistics conducted a compulsory census in March 1996. Our study was completed in May 1998. We have based our statistics on the New Zealand Census and calculated an overall incidence rate for retinal detachment within the population under study using direct age standardization. Incidence rates for sex and age together with other demographic data have been drawn from this information.

Cox proportional hazards modelling was used to assess the relative importance in developing RRD of sex, degree of myopia, history of trauma, and history of cataract surgery and whether it was complicated. All variables were entered into the model and the best subset of independent predictors discovered using a stepwise procedure. Choice of the final model was based upon the statistical significance of the parameter (P < 0.05), biological plausibility and parsimony. All tests were two-tailed.

RESULTS

There were 146 new RRD cases that presented in 141 patients, comprising 61 women and 80 men. The overall incidence rate was 11.8 (95% CI 9.8-13.7) per 100 000 people. The patients' ages ranged from 5 to 96 years with a mean age (± standard deviation) of 53.9 ± 19.6 years. The incidence of retinal detachment was maximal in the 60-69 years age group (Fig. 1) with a predominance of women in the first half of this decade (59%), and men in the later (65%). Overall, retinal detachment presented more commonly in men at a ratio of 1.3:1 (Table 1).

Ethnicity was not evaluated in this study. In this series most of the patients were in good health. Cardiovascular disease was recognized in 12% and respiratory disease, most commonly obstructive airway disease, was found in 5%. Over 13% (n = 19) of our patients were smokers. The age of patients who smoked ranged from 18 to 79 years. Voluntary disclosure of smoking in the 1996 Census confirmed a comparable percentage (14.2%) with the participants in the current study.

Ocular trauma preceded RRD in 16.4%. The majority of these patients had severe ocular trauma including penetrating eye injury, cataract wound dehiscence and globe rupture. Interestingly, 87.5% of those in the trauma group were under the age of 50 years, although this age group comprised only 35.6% of the total number of RRDs. The relationship between RRD and non-ocular trauma was not explored.

A number of patients presented with a history of surgical retinal disease. Thirteen patients gave a history of treated retinal tears in the eye with RRD and five patients had tears previously recognized in the fellow eye. Twelve patients had previous RRD in their presenting eye and another nine patients had involvement of their non-presenting eye. Five patients presented in this series with bilateral RRD.

### Table 1. Actual numbers and incidences of rhegmatogenous retinal detachment (RRD) within the northern New Zealand population for males, females and all individuals in 1997-1998

<table>
<thead>
<tr>
<th>Age range (years)</th>
<th>No. individuals (New Zealand census)</th>
<th>Total with RRD</th>
<th>Males with RRD</th>
<th>Females with RRD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Male</td>
<td>Female</td>
<td>Number</td>
</tr>
<tr>
<td>&lt;10</td>
<td>194094</td>
<td>99667</td>
<td>94427</td>
<td>3</td>
</tr>
<tr>
<td>10-19</td>
<td>174066</td>
<td>88839</td>
<td>85227</td>
<td>5</td>
</tr>
<tr>
<td>20-29</td>
<td>188346</td>
<td>91031</td>
<td>97315</td>
<td>18</td>
</tr>
<tr>
<td>30-39</td>
<td>203737</td>
<td>97181</td>
<td>106192</td>
<td>8</td>
</tr>
<tr>
<td>40-49</td>
<td>167658</td>
<td>81961</td>
<td>85697</td>
<td>14</td>
</tr>
<tr>
<td>50-59</td>
<td>113658</td>
<td>56568</td>
<td>57090</td>
<td>26</td>
</tr>
<tr>
<td>60-69</td>
<td>80481</td>
<td>39765</td>
<td>40716</td>
<td>40</td>
</tr>
<tr>
<td>70-79</td>
<td>58239</td>
<td>25309</td>
<td>32930</td>
<td>19</td>
</tr>
<tr>
<td>&gt;80</td>
<td>28779</td>
<td>9623</td>
<td>19156</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>1205694</td>
<td>589965</td>
<td>615729</td>
<td>141</td>
</tr>
</tbody>
</table>

*Incidence per 100 000 population, †incidence per 100 000 males, ‡incidence per 100 000 females.
We defined high myopia as that greater than -6.0 D. Thirty-three patients had myopia of this magnitude, some 23% of our patients. Forty-eight, or 33%, of eyes presenting with RRD had undergone cataract surgery. Two-thirds (n = 31) of the 48 eyes had undergone phacoemulsification as the method of cataract extraction with another 11 by extra capsular surgery. In six eyes the method of lens extraction could not be determined. In Fig 2 the time interval between cataract surgery and the retina detaching is shown. The longest interval was 38 years but almost 50% of detachments post cataract surgery occurred within 2 years of the cataract surgery, and approximately 75% of these were within 12 months of surgery. The numbers of patients having had evidence of YAG capsulotomy was too small (n = 5) for statistical analysis.

Univariate statistical models showed that having RRD earlier in life was associated with trauma, myopia beyond –6.0 D and the previous cataract surgery but not male sex. In a multivariate Cox proportional hazards model of the risk of early RRD there was a fourfold increase in the risk of early RRD in those experiencing trauma (4.1; 95% CI 2.6–6.6, P = 0.0001). Independently, myopia beyond –6.0 D increased the risk of early RRD by 90% (1.9; 95% CI 1.2–2.8, P = 0.0024) while previous cataract surgery independently increased the risk of early RRD by 90% (1.9; 95% CI 1.3–2.7, P = 0.0008). Sex was not independently associated with early RRD (P = 0.64).

We attempted to evaluate, in those patients who had had cataract surgery, whether there was evidence of complicated surgery (Fig. 2). Options included displaced intraocular lens, vitreous in the anterior chamber, peaked pupil, ruptured posterior capsule or simply 'complicated non-specific'. Fifteen patients were thus defined as having had complicated cataract surgery. Two-thirds of these patients developed a RRD within 2 years of their cataract surgery, but the range was from 3 weeks to 29 years. Comparing the time interval for developing a RRD in this subset of patients highlighted no statistically significant difference from those patients deemed to have had uncomplicated cataract surgery (P < 0.05).

Discussion

This study found the annual incidence of RRD in northern New Zealand is approximately 12 per 100 000 population (95% CI 10–14 per 100 000). This figure includes all patients presenting with retinal detachments and not solely those progressing to surgery. However, we did not include patients undergoing repeat surgeries within 4 months of any primary repair even if the break was at a site distant from the...
Table 2. Comparison of the incidence rates of rhegmatogenous retinal detachment (RRD) per 100,000 persons per year in Olmstead County, Minnesota, USA (averaged 1976–1995), Örebro and Värmland, Sweden (averaged 1976–1980) and northern New Zealand (1997–1998), according to age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>USA (n = 311)</th>
<th>Sweden (n = 289)</th>
<th>New Zealand (n = 141)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–29</td>
<td>5.0</td>
<td>2.3</td>
<td>4.7</td>
</tr>
<tr>
<td>30–59</td>
<td>18.3</td>
<td>10.4</td>
<td>10.0</td>
</tr>
<tr>
<td>60+</td>
<td>49.7</td>
<td>27.9</td>
<td>40.0</td>
</tr>
</tbody>
</table>

original pathology. We believe that, because of the circumscribed area, the active support of the ophthalmic community and access to both private and public patients, our report reflects accurately the absolute number of patients with RRD in northern New Zealand.

Similar studies documenting the incidence of RRD have reported both higher and lower annual rates than we have documented. Some of these differences may be explained by varying methods of data collection. For example some authors restricted their surveys to patients undergoing retinal re-attachment surgery, and others have excluded RRD following trauma and intraocular surgery. The Olmsted County Study included all patients presenting with RRD over a 20-year interval and found an annualized incidence rate of 17.9 per 100 000. This group did not exclude failed primary surgeries, which may account for their overall higher rate. However, this report did include aetiological groupings and age stratification, allowing for further comparisons with our data (Fig 3). The rates of RRD in our study group were consistently lower for all groupings (idiopathic, trauma, and following cataract surgery) with the exception of the pseudophakic population between the ages of 60 and 80, where the incidence was somewhat higher in the current study.

The comparison of the data from the current study with that from Örebro and Värmland in Sweden is more difficult due to the limited age stratification and absence of sex separation used in the latter study. However, a meta-analysis performed for the three studies, based on the age separation used in the latter study, revealed that from Örebro and Värmland in Sweden is more difficult due to the limited age stratification and absence of sex separation used in the latter study. However, a meta-analysis performed for the three studies, based on the age separation used in the latter study, revealed that the probability of RRD following cataract surgery was around 5.5–7.6 times the risk for a phakic eye. These studies did not evaluate the risk of RRD associated with complicated cataract surgery but this association is recognized and is believed to account for the sharp increase in frequency of RRD in the perioperative period. Our data does not enable us to reach any conclusion as to the perceived increase risk of RRD following cataract surgery, nor does it identify complicated cataract surgery as a heightened risk factor.

Previous retinal pathology, including a history of retinal detachment and/or retinal tears, was recorded in many of the patients in the current study. Tornquist et al. reported on rates of bilateral RRD over a 10-year period in Sweden and noted a prevalence of 11.2%, a much higher rate than the figure of 3.5% in the current study. The Swedish study also recorded those patients with a history of RRD in their presenting eye. They excluded cases with a recurrent RRD and a history (less than 6 months from the original surgery (compared with 4 months in our series) and reported a rate of 6.4%, compared to our rate of 8.2%. The frequency of bilateral and recurrent disease does not answer the debate on the merits of prophylaxis but highlights, for the individual patient, a need to be aware of the symptoms of retinal disease.

In summary, this report confirms that the risk of RRD is related to age, cataract surgery, myopia and a history of ocular trauma.

The results of the current study, consistent with previous studies, highlighted that ocular trauma, previous cataract surgery, and high myopia (> –6.0 D) were risk factors in the development of retinal detachment.

The Eye Disease Case-Control Study Group reported myopia as the single most relevant risk factor in the causation of idiopathic RRD, and conceivably this may account for lower numbers in the current study population if the prevalence of myopia is lower in the study area. Unfortunately the prevalence of myopia in New Zealand has not previously been documented in the literature.

Similarly we do not have access to numbers in the study population who have undergone cataract surgery but suspect like others, cataract surgery increases the risk of RRD. Most of the patients in the current study had undergone phacoemulsification and almost one-third (n = 15) were identified as having had complicated cataract surgery, a proportion which is well above the national average phacoemulsification complication rate of around 5%. Ten of these 15 developed RRD within 2 years, and nine were within 1 year. Both the Olmsted County Study and the International Cataract Surgery Outcomes Study demonstrated that the probability of RRD following cataract surgery was around 5.5–7.6 times the risk for a phakic eye. These studies did not evaluate the risk of RRD associated with complicated cataract surgery but this association is recognized and is believed to account for the sharp increase in frequency of RRD in the perioperative period. Our data does not enable us to reach any conclusion as to the perceived increase risk of RRD following cataract surgery, nor does it identify complicated cataract surgery as a heightened risk factor.

REFERENCES


Analysis of symptoms associated with rhegmatogenous retinal detachments

Philip J Polkinghorne FRCOphth and Jennifer P Craig PhD
Department of Ophthalmology, University of Auckland, Auckland, New Zealand

ABSTRACT

**Aim:** The symptoms associated with rhegmatogenous retinal detachments are variable and can be associated with other vitreoretinal and neuro-ophthalmic entities. The present study sought to determine the frequency and type of symptoms associated with rhegmatogenous retinal detachment (RRD), and analyse any relationships with the premorbid state.

**Methods:** An observational case series was undertaken. A patient questionnaire together with clinical data was collected for patients presenting with RRD.

**Results:** The data on 141 patients presenting with RRD were evaluated prospectively. More than 90% of patients reported a variety of symptoms including visual loss, floaters and flashes. The speed of visual loss was not associated with the extent of retinal break. Rather unexpectedly, patients with a history of retinal pathology were not any more likely to be symptomatic either in their presenting or fellow eye. The absence of symptoms was not associated with age, high myopia or previous cataract surgery.

**Conclusion:** Both patients and physicians need to be aware of the importance of the symptoms associated with RRD.

**Key words:** rhegmatogenous retinal detachment, symptoms.

INTRODUCTION

The visual outcome following successful retinal re-attachment surgery depends not only on the preoperative findings but also on the morbidity associated with the surgery. Consequently many techniques have been developed to minimize the risk of surgery and to prevent the development of comorbid pathologies such as cataract and ocular hypertension. A key indicator for visual outcome is the preoperative status of the macula. Retention of good central visual function is expected if the macula is attached at the time of surgery, but once the macula detaches, <75% of patients will achieve 6/12 or better. Furthermore, rapid surgical intervention in the presence of a detached macula does not improve the visual prognosis.

Regrettably many patients do not present until after macular detachment, and this delay in presentation prompted us to review the symptoms reported by patients in the evolution of a rhegmatogenous retinal detachment (RRD).

Not all patients presenting with RRD report premonitory symptoms, and unfortunately many of the symptoms associated with retinal detachment are not specific and overlap with both ageing changes in the vitreous as well as posterior vitreous detachment (PVD) and retinal breaks. However, the opportunity of being able to examine such patients does provide the occasion to educate the patient about the risks of vitreoretinal disease, as well as to develop a strategy should the symptoms change.

**METHODS**

We have previously reported on 141 consecutive patients who presented with RRD over a 12-month interval in a geographically confined area of New Zealand. All patients underwent a full ophthalmic history and examination. Particular care was taken during the enquiry to establish the presence or absence of symptoms, their duration and evolution, and these were recorded on a standardized recording sheet, for consistency between examiners. In the present series the mean age at presentation was 53 ± 19.6 years. The ratio of men to women was 1.3:1.

Thirty-four per cent of the patients had undergone cataract surgery prior to the development of RRD, and 29% of the remaining phakic patients were myopic. Five patients presented with bilateral RRD so there were 146 eyes available for the present study.

A number of patients had a history of surgical retinal disease including retinal tears and RRD (Table 1). We excluded only those patients with recurrent RRD in their presenting eye when the detachment recurred within 4 months of the previous surgery.
Table 1. Absolute numbers of patients with a history of retinal disease in the presenting and fellow eyes

<table>
<thead>
<tr>
<th>History</th>
<th>Presenting eye (n)</th>
<th>Fellow eye (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated retinal tears</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Retinal detachment</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 2. Ocular features in asymptomatic patients

<table>
<thead>
<tr>
<th>Asymptomatic cases</th>
<th>No. eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>14</td>
</tr>
<tr>
<td>Macula on</td>
<td>8</td>
</tr>
<tr>
<td>VA &lt; 6/36</td>
<td>4</td>
</tr>
<tr>
<td>VA ≥ 6/36</td>
<td>4</td>
</tr>
<tr>
<td>Macula off</td>
<td>6</td>
</tr>
<tr>
<td>Previous retinopexy</td>
<td>2</td>
</tr>
<tr>
<td>Previous retinal detachment in presenting eye</td>
<td>3</td>
</tr>
<tr>
<td>Asymptomatic fellow eye in bilateral presentation</td>
<td>2</td>
</tr>
</tbody>
</table>

VA, visual acuity.

Statistical analysis was performed using spss (SPSS, Chicago, IL, USA). Relationships between normally distributed parameters were established using linear regression analysis, and differences between parameters were determined by analysis of variance (ANOVA). A significance level of 5% was used throughout.

RESULTS

Most of the patients in the present series experienced a variety of symptoms prior to the diagnosis of RRD. Only 14 of the 146 eyes were asymptomatic, being detected on routine review by their ophthalmologist or primary healthcare provider in the vast majority of cases. The ophthalmic findings are summarized in Table 2. Eight of these 14 eyes presented with the macula attached, however, pre-existing macular pathology was present in half of these eyes with poor central visual acuity. Those patients with good acuity, yet who were asymptomatic, had either a peripheral detachment such as a dialysis or evidence of a chronic detachment such as atrophic retina, pigment lines, or subretinal bands. One patient included in the asymptomatic group developed a giant retinal tear (GRT) as a complication of cataract surgery and had retinal surgery on the same day. Of the five patients (3.5%) who presented with bilateral RRD, three patients were symptomatic in both eyes with the remainder asymptomatic in their fellow eye.

Further analysis of those patients with asymptomatic RRD revealed no clear relationship with symptoms, age, sex, myopia or previous cataract surgery.

A total of 18 patients had had previous retinopexy for presumed retinal breaks, including 13 eyes that had undergone treatment to the presenting eyes. Analysis revealed that these patients were no more likely to be symptomatic than those patients without a history of retinopexy (P > 0.05). A statistically significant difference was established between those patients with and without a history of previous retinal detachment repair but, rather unexpectedly, patients with a history of RRD were more likely to be asymptomatic. (ANOVA F = 5.873, P = 0.017).

The patients with symptomatic RRD reported a variety, and often a combination of symptoms including flashes, new floaters, and shadows of varying intensity, loss of vision, dyschromatopsia, and ocular pain. The number and variety of symptoms for those patients reporting a maximum of two symptoms are recorded in Table 3. Fourteen patients had a combination of three symptoms, and six patients reported four symptom types. Some patients reported an evolving pattern of symptoms, but no consistent pattern emerged in either the group as a whole or within a subset.

Forty-one patients gave a history of floaters, which varied from small mobile dark dots to undulating obscurations that covered much of the visual field. There was no statistically significant relationship established between a history of floaters, the age or gender of the patient, or myopic status, history of previous cataract or previous retinal pathology.

Most of the patients (65%) with floaters presented within 7 days of becoming symptomatic but the range was from 1 to 70 days.

Flashes, when reported, were typically silvery, in the temporal field and were most prominent under mesopic conditions. The duration of the flashing lights varied from 1 day to 6 months. Approximately half of the patients (55%) experienced flashing lights for ≤1 week. Those patients with flashing lights (n = 22) reported that this symptom persisted until presentation, whereas many patients reported that the floaters disappeared with time.

A small number of patients (n = 3) reported dyschromatopsia, typically a greenish hue, and this symptom tended to precede the development of a shadow. Once the shadow developed the dyschromatopsia vanished.

Description of shadows, curtains, or peripheral obscurations was reported in 53 eyes prior to presentation with RRD. The evolution of this symptom varied considerably (between 1 and 21 days), but the vast majority of patients (86.8%) again presented within 7 days of becoming symptomatic.

Table 3. No. patients reporting up to two symptoms prior to the presentation with RRD

<table>
<thead>
<tr>
<th>Flashes</th>
<th>Floaters</th>
<th>Shadow</th>
<th>Loss of vision</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashes</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Floaters</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Shadow</td>
<td>8</td>
<td>19</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Loss of vision</td>
<td>39</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bold, patients reporting a single symptom; not bold, patients declaring two symptoms.

RRD, rhegmatogenous retinal detachment.
Table 4. Comparison of symptoms and history of RRD

<table>
<thead>
<tr>
<th>Symptoms Noticed</th>
<th>Patients without previous RRD (%)</th>
<th>Patients with previous RRD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No symptoms</td>
<td>7.2</td>
<td>23.8</td>
</tr>
<tr>
<td>1 symptom</td>
<td>47.2</td>
<td>38.1</td>
</tr>
<tr>
<td>2 symptoms</td>
<td>32.0</td>
<td>23.8</td>
</tr>
<tr>
<td>3 symptoms</td>
<td>8.8</td>
<td>14.3</td>
</tr>
<tr>
<td>4 symptoms</td>
<td>4.8</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Patients with a history of RRD were more likely to be asymptomatic than those who were presenting with a retinal detachment for the first time (P = 0.017). Conversely, no significant difference was found in those subgroups of patients who were symptomatic

RRD, rhegmatogenous retinal detachment.

symptomatic. There was no statistically significant relationship between the location of the retinal break and the extent of the break (ANOVA, P = 0.801), but the shadow duration was related to the retinal break location such that superior breaks progressed more rapidly than inferior breaks (3.8 ± 3.3 days compared with 6.9 ± 6.2 days; ANOVA, P = 0.023).

There was no statistically significant correlation between the extent of the retinal break and shadow duration (R² = 0.026, P = 0.264). Similarly in phakic eyes the shadow did not progress any faster or slower than that in pseudophakic or aphakic eyes (ANOVA, P = 0.223).

Nine patients reported an ocular or periocular pain prior to presenting with a retinal detachment. This symptom lasted for up to 14 days and typically was of a diffuse, boring nature. It was not severe. In the majority of these patients with multiple symptoms, this symptom preceded all others.

The single commonest symptom was in fact loss of vision. Interestingly patient self-awareness of an RRD does not appear to be greater in that cohort who has previously experienced an RRD in either the presenting or fellow eye. This observation might support the view that regular review of all patients with a history of RRD is prudent, although the question of timing of such reviews is beyond the scope of the present study.

Tanner et al. reviewed the symptoms in a consecutive series of patients presenting with primary retinal detachment but excluded those eyes that had undergone previous intraocular surgery, including cataract surgery. They also excluded patients who had undergone retinopexy or previous retinal detachment surgery. We did not apply such exclusions because in the present series one-third of patients presenting with retinal detachment had had previous cataract surgery, an observation in keeping with other authors. Furthermore nearly 20% of patients in the present series had previous retinal pathology including retinal tears and/or retinal detachments. We excluded only those eyes with identified, recurrent disease within 4 months of presentation. In spite of the different selection criteria there are certain qualitative similarities between this study and that of Tanner et al. In both studies field or visual loss was the most frequently reported symptom, with asymptomatic RRD being relatively uncommon.

In the Duke Elder lecture of 1989 Scott reported on a study, conducted in his department, reviewing the symptoms of 50 consecutive patients presenting with RRD. He did not exclude patients with previous cataract surgery. In his series 14% of patients were asymptomatic. Those symptoms reported included peripheral flashes, scintillations, floaters, field loss and blurring. Scott has subsequently emphasized the importance of blurring of vision and field loss in patients with RRD (Scott J, personal communication, 2003).

That we did not demonstrate a relationship between symptoms of retinal detachment and the degree of myopia, cataract history and previous retinal pathology may be reflected in the small subgroups in our study. Furthermore, unlike some other reports we did not find that myopes were more likely to have asymptomatic RRD.
Our study confirmed the observation that patients with bilateral RRD need not be symptomatic in both eyes. Furthermore, Brod and Flynn, and Brod et al. demonstrated that patients with bilateral but asymptomatic RRD can progress and may require treatment. 

Conversely, Byer, when studying the natural history of asymptomatic retinal breaks, noted a subgroup of 17 subclinical retinal detachments. During his period of observation, ranging up to 12 years, none progressed to require surgery. Again such differences may be due to multiple factors. In Byer's series the patients were from a nonselected general population, but excluded from the analysis were patients with a history of intraocular surgery and previous retinal pathology. In the present series these patients, arguably with higher risk factors, were included.

In the present series 10% of the patients had asymptomatic RRD. They included bilateral RRD, as well as patients with high-risk features such as previous retinal pathology including previous retinal detachment, myopia and history of cataract surgery. Although the absence of symptoms in this group does not negate the otherwise effective public education programme in detecting 90% of the patients in the present series, it does highlight the need for ophthalmologists to be aware that not all patients with RRD are symptomatic.

REFERENCES


History of Ophthalmology

History of retinal surgery in New Zealand

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ABSTRACT
The history of retinal surgery in New Zealand is relatively short but covers a period of transition from caustic cautery to laser retinopexy, from scleral shortening to 25 gauge vitrectomy. The practitioners of this craft include some of the notable figures in medicine in New Zealand, and in their own way each contributed to the welfare of those patients with surgical retinal disease.

Key words: history, New Zealand, retinal detachment.

INTRODUCTION
The modern history of retinal surgery has its beginnings in Europe in the 1920s when Jules Gonin successfully devised a method for inducing retinopexy. Gonin subsequently described his approach to retinal detachments and collated his experience, complete with beautiful drawings, in his treatise *Decollements de la Retine.* A copy of this book was gifted to Harold Coop by a student of Gonin’s, Professor Rene Dufour, and remains in a private collection in New Zealand. The retinal drawings are perhaps even more impressive when one considers Gonin used a direct ophthalmoscope to document his findings.

Although Gonin reported excellent results with his techniques, there were technical difficulties associated with inducing retinopexy by cautery. Furthermore some eyes, in particular those with chronic retinal detachments, less mobile retinas and viscous subretinal fluid, were more difficult to re-attach.

To address some of these issues a variety of scleral shortening techniques were advocated that facilitated the approximation of the retina to the choroid.

Shapland, who subsequently had a special influence on retinal surgery in New Zealand, popularized a lamellar scleral resection technique for this group of patients. Other workers devised alternative methods of retinopexy including diathermy and chemical cauterization. These alternative approaches proved to have advantages in eyes with multiple or large retinal breaks.

METHODS OF RETINOPEXY
Professor John Parr of Dunedin was a registrar of Shapland when the latter was a Consultant at Moorfields Eye Hospital. When Professor Parr returned to New Zealand in the early 1950s, he adopted many of Shapland’s techniques and, having had experience with caustic potash as a method of inducing retinopexy, was able to use this agent until a diathermy unit was purchased by Dunedin Hospital. Shapland subsequently visited New Zealand in 1961 presenting some of his work at the annual meeting of the Ophthalmic Society of New Zealand.

The first commercially available diathermy machine for ophthalmic use in New Zealand was the uni-polar 700B Keeler Major Electro-Surgical Unit. (Keeler R, personal communication.) The electrodes available with this unit enabled both trans-scleral and penetrating diathermy to be performed. The former, although easier to execute, often produced a variable reaction on the choroid as sclera is a poor conductor of heat. Furthermore the thermal damage to the sclera induced by the diathermy tended to preclude further surgeries being performed. The technique of penetrating diathermy required the fashioning of a scleral flap that enabled the diathermy probe to approximate the choroid. This meant the diathermy could be applied with a more measured effect but in eyes with thin sclera and multiple breaks the technique was time consuming and technically difficult. These difficulties, together with the realization that cryotherapy could also induce retinopexy, led to the abandonment of diathermy in New Zealand. By the early 1960s the application of liquid nitrogen to the sclera was the method of choice in New Zealand.

The standard method was to pour liquid nitrogen into a funnel joined to a metal tube that was held close to the sclera. An ice ball formed on the sclera, was left for a suitable interval, and then thawed by the irrigation of normal saline. Liquid nitrogen was freely available from industrial suppliers during this period but the inability to store the liquid in the hospital environment was a major difficulty. Mr Cecil Pittar in Auckland accessed his supply from Industrial Cases Ltd for seven and six pence a pint. However, it was the advent of the Amoils ‘Cryo Pencil Unit’ in the mid 1960s that revolutionized the use of cryotherapy in ophthalmology.

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Amoils designed a probe that utilized the Joules Thompson principle. Sir William Thompson, better known as Lord Kelvin, had discovered if compressed gas was allowed to expand rapidly, a reduction in temperature would occur. The device Amoils designed consisted of a fine probe through which gas could be vented in a controlled fashion. The resultant reduction in temperature caused an ice ball to form on the probe tip that could induce retinopathy. The retinal probe was somewhat larger than the probe used during cataract surgery but the usefulness of this device meant the Cryo Pencil Units quickly became available in most ophthalmic departments in New Zealand. Cryotherapy as a method of inducing retinopathy remains popular to the present day.

The Surgeries

Retinal re-attachment surgery had been performed in New Zealand prior to the return of Professor Parr but the numbers were small and functional success was variable. Simple methods of treatment included bed rest and positioning, with surgical intervention being reserved for desperate cases. Most surgeries were performed under general anaesthesia and the list of relative contraindications considered important in New Zealand in the 1950s tended, together with the difficulties associated with retinal surgery, to restrict the number of surgeries. Despite of obvious difficulties retinal surgery was regularly being performed in most metropolitan centres in New Zealand in the mid to late 1950s.

In Christchurch, Dr W (Lindsey) Burns was considered as having special expertise. He had been elected to the Ophthalmic Society of the United Kingdom in 1948 and was a foundation member of the Ophthalmic Society of New Zealand. Dr Burns was an Honorary Consultant at Christchurch Hospital and had an extensive private practice. He contributed to the first epidemiological study into retinal detachments in New Zealand. This work was published in 1968 by Suckling and Hay and determined the incidence of retinal detachment in the Christchurch region was 1 per 20,000 persons per year. The same group of surgeons also determined the risk of retinal detachment to the fellow eye was 8%. This figure is lower than the values generally quoted today, which may reflect the differences in accessing treatment, mortality and the exclusion criteria adopted in the Christchurch study.

Training and influences in retinal surgery

Up until the mid 1970s speciality training for ophthalmology was limited in New Zealand. Most wishing to pursue a full time career in ophthalmology therefore travelled abroad, mostly to the UK, and undertook training in the London hospitals or at other major centres such as Manchester or Edinburgh. The subsequent influence on retinal practice in New Zealand tended to therefore emanate from these quarters. Thus although Schepens designed a self-illuminating binocular indirect ophthalmoscope in 1945, it was the Fison indirect ophthalmoscope that found favour in New Zealand. Hylton Le Grice who worked with Fison was instrumental in introducing indirect ophthalmoscopy when he returned to New Zealand in 1967. Fison subsequently visited New Zealand in 1967 as a guest of the Ophthalmic Society of New Zealand and toured the country providing practical advice.

Many of the ideas for improving retinal practice continued to originate from Europe in the twentieth century and the contributions of Meyer-Schwickerath in 1950s with the development of the photocoagulator are notable. Zeiss gained the manufacturing rights and in 1969 the first Zeiss photocoagulators were introduced to New Zealand. At the Ophthalmologic Society of New Zealand meeting in 1971, Mr Richard Reynolds reported on its efficacy. Although the photocoagulator could be used in the treatment of flat retinal breaks, the main indication was in medical retinal practice particularly for retinal vascular diseases. In New Zealand, the Zeiss photocoagulator was only occasionally used for surgical retinal cases. Cryotherapy was considered more versatile and remained popular.

Consolidation of sub-speciality practice

The era of subspecialization had its beginnings in New Zealand in 1969 when Harold Coop was appointed as the first retinal specialist at Auckland Hospital. Dr Coop, like many of his contemporaries, was trained at Moorfields, working with such notable surgeons as Rolf Blach and Lorimer Fison. His knowledge and skill both in New Zealand and the Pacific Islands ensured an extensive retinal practice, which he continued until the 1990s. Coop was a master of conventional retinal detachment surgery and returned this focus through out his professional life. He introduced to New Zealand that generation of explants that followed the Custodis polyviol implants including the silicone sponges and solid silicone explants. Coop was the first in New Zealand to inject silicone oil to eyes with retinal detachments. This technique, popularized by Blach, involved injecting silicone oil into the vitreous cavity, in a non-vitrectomised eye, as subretinal fluid was drained through a sclerotomy. In 1971 W (Bill) Taylor returned to New Zealand and quickly developed a reputation for managing a prodigious retinal work load. Taylor, also Moorfields trained, was a meticulous surgeon and keen observer. Together with Peter Hamilton he described the presence of cigarette dust in the vitreous cavity as an indicator of a retinal tear. Unfortunately this sign, which was independently recognized by Shafer, is more commonly referred to as Shafer's sign.

Taylor's first passion was medical retina but he continued performing retinal surgery with skill until he retired for the second time at the age of 60.
FROM VITREOUS SURGERY TO THE PRESENT

The first account of vitreous surgery being performed in New Zealand was in Wellington in 1949 by Barrie Jones. His case report described a young boy with a retained non-magnetic intraocular foreign body in an eye with opaque media. Jones devised a method whereby an electromagnetic current applied to the base of a pair of forceps could be tuned to providing an audible signal as the forceps approximated the foreign body. Indeed the technique proved to be effective in enabling the foreign body to be removed, sight unseen.² This apparatus was further adapted by Keeler in London and subsequently marketed as the Roper-Hall Foreign Body Locator.

In 1976 Bruce Hadden performed the first planned vitrectomies in New Zealand. The vitrectors of this era were multifunctional and contained within a single hand piece both vitreous cutter and infusion line. These instruments were called a vitreous infusion cutter, or VISC. The cutter was powered by a motor in the hand piece and aspiration controlled by an assistant who created negative pressure by aspirating on a syringe. The intraocular pressure was regulated by adjusting the height of the infusion fluid, usually Hartmann’s solution.

The standard operating microscopes available in New Zealand during this period did not have X–Y movement and together with the comparatively dim and flimsy light pipes meant surgery was nearly always technically difficult. Indeed the initial surgeries were restricted to clearing vitreous haemorrhage and relieving vitreous traction. The first case reports were reported in the Transactions of the Ophthalmic Society of New Zealand in 1977. John Bowbyes, who was then resident in Dunedin, reported on seven eyes with good results while Hadden reported on a similar number from Auckland.⁵,⁶

Hadden was the first New Zealander who received subspecialty training in surgical retina in the USA, an indication of the perceptible shift of influence across the Atlantic. Hadden and Taylor both practised in Auckland and subsequently joined forces and formed the first New Zealand private retinal subspecialty group. They invested in contemporary technologies, acquiring a suite for fluorescein angiography and argon laser photocoagulation. They were instrumental in the shift to 3-port vitrectomy surgery and acquired for both public and private sectors the new Ocutome vitrector. This instrument, revolutionary at the time, provided for automated and controlled aspiration. It contained a bright, state-of-the-art, halogen light source and was equipped with a reusable cutter. Many other centres in New Zealand subsequently acquired this technology.

In the 1980s Grieshaber introduced the air pump enabling easier fluid air exchange. An air pump was subsequently incorporated into the next generation vitrectomy machine, called the Series 10 000, which was manufactured by Alcon Laboratories.

Although patients with advanced diabetic eye disease remained a common indication for vitrectomy surgery, it was not until 1990 that a laser with a facility for intraocular use became available in New Zealand. Prior to this, diabetic patients who were likely to require intraoperative laser photocoagulation had to apply for funding and seek treatment abroad, most often in the USA. In the late 1980s 2–3 patients per year sought such assistance. Ultimately in response to repeated requests, the Ministry of Health provided funding for the purchase of a laser with both an endolaser and laser indirect facility. The Novis photocoagulator was made by Coherent and was relatively mobile at 120 kg. The quid pro quo was that Auckland became the tertiary referral centre for vitreo-retinal surgery in New Zealand. This state of affairs did not persist for long as other centres (Christchurch, Hamilton, Wellington and more recently Tauranga) attracted ophthalmologists with subspecialty training in vitreoretinal surgery.

This increase in human resources matched by improvements in technology and communication has fostered the development of formal research programs and created an environment where the unique problems confronting New Zealand can start to be answered.

ACKNOWLEDGEMENTS

The authors are grateful to those senior colleagues who provided the background material for this paper, particularly those who took the trouble to collect cases and write of their experiences in the fledgling Transactions of the Ophthalmic Society of New Zealand. The authors are indebted to Mr R Keeler FRCOphth (Hon) Curator of the Historical Section at the Royal College of Ophthalmologists.

REFERENCES

Pseudophakic retinal detachment after phacoemulsification cataract surgery

Ten-year retrospective review

Matthew Russell, FRANZCO, Brent Gaskin, MB, ChB, Daniel Russell, BAgSci, MVS(Epi), Philip John Polkinghorne, FRANZCO

PURPOSE: To determine the risk for rhegmatogenous retinal detachment (RRD) after phacoemulsification.

SETTING: Private and public facility, Auckland, New Zealand.

METHODS: A retrospective study of 1793 consecutive patients having cataract surgery by phacoemulsification was performed. Patients younger than 40 years were excluded, as were patients who had cataract surgery after ocular trauma. Patients having cataract surgery combined with other ocular procedures such as keratoplasty, glaucoma drainage surgery, or posterior segment surgery were similarly excluded.

RESULTS: Rhegmatogenous retinal detachment occurred in 1.17% of the patients having cataract surgery. The risk was greater in patients younger than 50 years (5.17%) and less in those older than 70 years (0.64%). The median interval between cataract surgery and development of the retinal detachment was 39 months. The rate of retinal detachment was greater with complicated cataract surgery, but there was no increased risk for those eyes requiring neodymium:YAG laser capsulotomy.

CONCLUSIONS: The overall risk for RRD after cataract surgery by phacoemulsification was small. However, in the younger patient, the risk for pseudophakic detachment was higher. In light of this finding, the requirement for cataract surgery in this group should be reassessed.

In the past 15 years, phacoemulsification has become the preferred technique for cataract surgery in the developed world. The surgery has enabled patients to achieve better functional results in a shorter time than with extracapsular techniques. Furthermore, most studies have found the overall complication rate with phacoemulsification to be reduced. Conversely, the rate of rhegmatogenous retinal detachment (RRD) after cataract surgery has not been reduced significantly by the shift to phacoemulsification.
surgery after ocular trauma were excluded, as were patients who
had planned or unplanned extracapsular cataract surgery. Similarly,
patients having cataract surgery combined with other ocular
procedures such as keratoplasty, glaucoma drainage surgery, or
posterior segment surgery were excluded.

All the surgeries were performed at 1 institution and were
identified from the operating room records. The operating sur-
gon was contacted, and free access to the patients’ records was re-
quiested and, in all cases, granted. The demographic data and
surgical details were recorded, as was the patient’s last follow-up
visit. Where available, the axial length, other ophthalmic param-
eters, and details of previous or subsequent ophthalmic history
were recorded.

Every patient having cataract surgery during the period of
review was systematically cross checked with the regions vitreo-
retinal database, which includes both public and private surgeries.
In addition, the patient’s name, date of birth, and National Health
Index (NHI) number was matched against the database recording
all public health sector admissions, where the admitting, current,
and past diagnoses are recorded. Auckland City Hospital was
the region’s only public facility in which retinal surgery was Per-
duced during the period under review. The endpoint of the study
was 10 years from the date of the cataract surgery or when the
patient died.

The relative importance of sex, age, axial length, complicated
cataract surgery, and Nd:YAG capsulotomy was evaluated using the
Fisher exact test. A significance level of 5% was used throughout.

RESULTS

During the review period, 1793 consecutive eyes of 1547
patients who had phacoemulsification cataract sur-
gery were identified. Ten experienced cataract surgeons
performed the surgeries using the Allergan Sensory V. More than 95% of eyes had posterior chamber intraocular
lenses inserted at the time of surgery (Table 1).

The mean age of the patients having cataract surgery was
73.6 years (range 40 to 100 years). Five hundred se-
venty-three patients were men (37%), and 974 were women
(63%). Ninety-five men and 161 women had second-eye
surgery during the study period. Three hundred fifty-eight
patients (23%) died in the 10-year interval after the original
surgery and development of a RRD was 39 months (range
1 to 120 months). There was no period of increased risk for
RRD. One fifth (4 of 21) of the RRDs occurred within the
first 12 months of surgery. The risk for RRD was 5.17% in
those patients younger than 50 years compared with 0.64% for
those patients older than 70 years. This difference was
significant (P = .02). Overall, the incidence of RRD was
higher in men (2.10%) than in women (0.62%; P = .01).

Axial lengths in 1262 eyes were available (Table 3). The
distribution curve of axial lengths was analyzed, and
patients were assigned arbitrarily into 2 groups: those
with axial lengths less than 24 mm and those with lengths
greater than 24 mm. It was found that the risk for RRD was
4.87 times higher in eyes that had an axial length measure-
ment of 24 or greater (P <.01). There were 71 eyes with
axial lengths of 25 mm or greater, and 2 of these eyes had
RRD. The sample size of this latter subgroup precludes
useful conclusions being drawn.

In total, 95 eyes had a complicated surgical event
recorded, equating to 5.2% of all surgeries. Thirty-three
eyes had posterior capsule rupture at the time of surgery,
including 24 that required an anterior vitrectomy. Two
eyes that required an anterior vitrectomy had a retinal de-
tachment in the follow-up period, whereas another 2 eyes
with capsule rupture also progressed to RRD (Table 4).

Three hundred thirty-two eyes had an Nd:YAG capsu-
lotomy during the period of review (Table 5). This did not
lead to an increased risk for RRD (P = .57). The mean age
in this subgroup was similar to that in the overall group,
suggesting age was not a confounding factor. Furthermore,
eyes with axial lengths greater than 24 mm having an
Nd:YAG capsulotomy were not more likely to have RRD
than eyes with an axial length less than 24 mm.

Table 1. Intraocular lens selection.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Surgeries (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior chamber IOL</td>
<td>1748 (97.5)</td>
</tr>
<tr>
<td>Anterior chamber IOL</td>
<td>37 (2)</td>
</tr>
<tr>
<td>No IOL</td>
<td>8 (0.5)*</td>
</tr>
</tbody>
</table>

IOL = intraocular lens

*Eyes in which estimated postoperative refraction approximated emme-
tropia or balanced the refraction in the fellow eye

Table 2. The relationship between age of the pseudophakic patient and
mortality.

<table>
<thead>
<tr>
<th>Age Group (Y)</th>
<th>No. of Patients (%)</th>
<th>No. Died (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50</td>
<td>54 (3)</td>
<td>1 (&lt;1.0)</td>
</tr>
<tr>
<td>50 to 59</td>
<td>112 (7)</td>
<td>4 (&lt;1.0)</td>
</tr>
<tr>
<td>60 to 69</td>
<td>320 (21)</td>
<td>32 (2.0)</td>
</tr>
<tr>
<td>&gt; 70</td>
<td>1061 (69)</td>
<td>321 (20)</td>
</tr>
</tbody>
</table>

Table 3. Correlation between RRD and axial length.

<table>
<thead>
<tr>
<th>Axial Length (mm)</th>
<th>No. of Eyes</th>
<th>No. of Retinal Detachments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;23</td>
<td>601</td>
<td>5</td>
</tr>
<tr>
<td>23 to 24</td>
<td>456</td>
<td>6</td>
</tr>
<tr>
<td>&gt;24</td>
<td>205</td>
<td>9</td>
</tr>
</tbody>
</table>

Axial length measurements were available for 1262 eyes. One RRD
occurred in an eye without a readable axial length measurement.
A few patients in this series had, before cataract surgery, a history of retinal detachment surgery. Eleven had RRD surgery in the presenting eye, and 2 of these eyes had a retinal detachment during the observation period (P = .10). Similarly, 1 of 4 patients with a history of a retinal detachment in the fellow eye had a retinal detachment in the pseudophakic eye under review (P = .046).

**DISCUSSION**

The risk for RRD after phacoemulsification is not well defined. Previous studies have been hampered by results from a single surgeon, limited follow-up period, and an inability to capture all patients with RRD. Furthermore, it is not clear in some series whether the eye with RRD was the eye that had cataract surgery or what surgical technique was used to remove the cataractous lens. In spite of these limitations, estimates of risk have been formulated, suggesting cataract surgery is responsible for 94% of RRDs occurring within the first year after surgery, or, alternatively, the cumulative probability of developing RRD is 5.5 times greater than expected for a comparison group not having cataract surgery.11-20

In New Zealand, the geographical isolation of the country, together with vitreoretinal services being localized to the major centers, tends to inhibit movement of patients to other health care providers. Indeed, we previously documented an ability to capture 98% of all patients with RRD presenting in the Auckland region using a surgical vitreoretinal database as an endpoint. In our study, we evaluated the risk of a history retinal detachment after cataract surgery by any method presented within 2 years of surgery and 90% within 10 years.

In the current series, the median interval between cataract surgery and the development of a RRD was 39 months. The duration of this latent period has been noted by other authors and highlights the importance of prolonged follow-up if accurate incidences of pseudophakic RRD are to be determined.24,25

The overall risk for a retinal detachment after cataract surgery by phacoemulsification in our series was 1.16%, but the risk was greater in men and pseudophakic patients younger than 50 years. Olsen et al. noted in their series of 58 patients younger than 60 years and with axial lengths less than 24 mm that there was a zero risk for RRD, whereas 3 RRDs occurred in 56 eyes with axial lengths of 24 mm or greater. In our series, the increased risk for RRD in the younger patient was independent of axial length.

In our study, we evaluated the risk of a history retinal detachment. While some statistical results were obtained, we believe the numbers in our series are too small to draw meaningful conclusions.

In 1985, Chambless reported 3047 consecutive cases of extracapsular cataract surgery using a Cavitron unit, which enabled the nucleus to be removed by emulsification. In his series, the rate of retinal detachment was 0.39%, with RRD occurring more frequently in eyes with open capsules, particularly with vitreous disturbance. He reported postoperative capsulotomy was required in 36% of eyes in his series, most having a Ziegler knife discission. More recent accounts evaluating the association of Nd:YAG capsulotomy and retinal detachment have shown a slight or zero increase over eyes with intact posterior capsules. In our series, we did not find an increased risk for RRD in the 333 eyes having Nd:YAG capsulotomy, with or without axial myopia.

Axial myopia was a risk factor for RRD in the current series, although not all eyes had readable axial lengths. Unfortunately, biometry recordings in the 1990s were typically printed on thermal paper, and the legibility of the results in 531 eyes could not be read at the time of data analysis. We do not believe the lack of complete data introduced a bias into the study as unreadable scans occurred with all surgeons and at varying time intervals. Eyes with axial lengths greater than 24 mm were more likely to have RRD when matched for age and sex. Alldredge et al. also reported 80 eyes with high myopia having phacoemulsification, including 64 eyes with axial lengths of 25.0 mm. No patient in their series had RRD, and the conclusion drawn was that modern cataract surgery is equally safe in eyes with high myopia. Similarly, Fan et al. report 118 eyes having cataract surgery with axial lengths greater than 26.0 mm, 2 of whom had RRD. In Fan et al.'s series, a vigilant search was undertaken for retinal tears presurgery and postsurgery.

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**Table 4. Absolute number of intraoperative complications during cataract surgery measured against retinal outcome.**

<table>
<thead>
<tr>
<th>Complication</th>
<th>+RRD</th>
<th>−RRD</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complicated surgery</td>
<td>5</td>
<td>90</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Capsule rupture</td>
<td>2</td>
<td>31</td>
<td>.056</td>
</tr>
<tr>
<td>Anterior vitrectomy</td>
<td>2</td>
<td>22</td>
<td>.031</td>
</tr>
</tbody>
</table>

+RRD = eyes with RRD; −RRD = eyes without RRD

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**Table 5. Association between Nd:YAG laser capsulotomy and RRD.**

<table>
<thead>
<tr>
<th>Nd:YAG Capsulotomy</th>
<th>No. of Eyes (%)</th>
<th>No. of RRD</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>1,461 (81)</td>
<td>17</td>
</tr>
<tr>
<td>Yes</td>
<td>332 (19)</td>
<td>4</td>
</tr>
</tbody>
</table>

RRD = rhegmatogenous retinal detachment
Eyes having capsulotomy did not have an increased risk for retinal detachment (P = 0.57).
and prophylactic laser treatment was applied when such a lesion was identified. Conversely, other groups have found prophylactic laser photoocoagulation did not eliminate pseudophakic RRD in myopic patients.31,32

In our series, no prophylactic strategy was adopted, and 2 eyes with axial lengths greater than 25 mm had RRD. Unfortunately, when the confounding factors of age and sex were taken into account, we concluded our sample size was too small to draw useful conclusions.

In our series, 26% of the patients died in the 10-year follow-up period. These patients were censored from the date of death and were treated as having attached retinas until this date. Many reports have ignored the effect of death, leading to perhaps erroneous conclusions that surgery is safer in certain groups.15,16 In the current series, the mortality rate was higher in the aged but the risk for RRD in the elderly was lower, even when corrected for the higher death rates.

The risk of pseudophakic RRD in patients having cataract surgery by phacoemulsification is relatively low, even if surgery is complicated and a postoperative Nd:YAG capsulotomy is necessary. However, the incidence of RRD is adversely affected by the presence of axial myopia and the presence of a presenile cataract.

REFERENCES


