The mechanism of accommodation and its relevance to presbyopia has been debated since Victorian times, and the arguments are still surprisingly vehement. Are new data bringing us any closer to a resolution?

Sir Arthur Conan Doyle, author of the Sherlock Holmes books, also wrote a book called The Lost World, dominated by a brilliant and infuriated arrogant scientist, Prof. Challenger. After an expedition to the lost world - a remote and inaccessible plateau in South America, where dinosaurs still roam - Challenger returns to London to present his findings to a public meeting of the Royal Society. A ferocious argument erupts, which is only resolved when the professor lets loose a pterodactyl, which flaps slowly around the Natural History Museum, before escaping through a window.

Science doesn't usually arouse such high passions these days, though we still rely on data - if a pterodactyl can be regarded as a datum – to support any conclusions. The Lost World was written in 1912, more than half a century after Helmholtz started another long-running and at times equally acrimonious debate, now 150 years old, on the mechanism of accommodation. Despite the release of a whole pack of pterodactyls, or at least data, the debate still retains a Victorian sense of melodrama and personality, and indeed some protagonists do occasionally come alarmingly close to blows.

In essence, Helmholtz argued that constriction of the ciliary muscle releases the tension on the zonules, leading to a relaxation and rounding of the lens, so increasing its power. Some 40 years later, Tscherning argued more or less the opposite: that ciliary-muscle contraction increases the tension on the zonules, thereby altering the shape of the lens without changing its thickness. Another prominent theory, originally postulated by Mueller around 1854, and given modern form by Coleman, is that accommodation is achieved through anterior movement of the lens, under pressure from the vitreous. But it was the resurrection of Tscherning's conception by Schachar in the 1990s that re-injected the resurrection of Tscherning's conception under pressure from the vitreous. But it was Coleman, in particular almost no cases of anterior segment ischemia, conjunctival erosion, irritation or inflammation.

Despite improvements in the implants, the most common complication was still subluxation. Dr. Soloway noted a total of eight cases. In a sense, however, subluxation provided a proof of concept: "Visual acuity deteriorated during subluxation, in some cases to 20/80 or worse, and was restored to 20/40 or better when we corrected the subluxation."

Dr. Thornton sees the results as vindication for his own technique of ciliary sclerotomy, which he argues is safer and more effective, utilising as it does four radial incisions to the ciliary body, rather than the transverse incisions of scleral spacing but in both cases the intention is to expand the globe, increasing the space and freedom of movement in the anterior segment - freeing the lens from 'crowding', as Dr. Thornton puts it.

"Visual acuity deteriorated during subluxation, in some cases to 20/80 or worse, and was restored to 20/40 or better when we corrected the subluxation."
Adrian Glasser, PhD, at the University of Houston, is equally sceptical.

"I'm afraid I just don't accept that this study has demonstrated accommodation, only perhaps at best multifocality, or changes in the depth of field of the eye," Dr Glasser told EuroTimes.

A number of patients treated with scleral spacing have been referred to Dr Glasser, Dr Steven Mathews, PhD, Texas Tech University, Lubbock, and Prof Jay Pepose MD, PhD, of the Pepose Vision Institute, St Louis, Missouri, to measure accommodation directly using either a dynamic infrared ophthalmometer or an objective Hartinger and a Grand-Seko refractometer (which the phase III trial did not do).

Dr Glasser is plain: "There hasn't been any evidence of improved accommodation in any case out of the 10 patients that have been measured directly, objectively, so far."

While all applaud any technique that brings about direct benefits to visual acuity, at present it is only fair to conclude that scleral spacing procedures have not yet proved anything one way or the other about the mechanism of either accommodation or presbyopia.

Hiding behind the iris

Such controversies over measurement have bedevilled the whole field for a long time.

"Much of the disagrement stems from the difficulties in seeing the ciliary body and zonules behind the iris," Prof Koretz told EuroTimes. But there have been a handful of cases of aniridia and albinism, where the whole lens can be observed with retroillumination. "These have always supported the Helmholtz mechanism," she said.

Probably the most compelling findings have come from high-resolution MRI imaging, in work done by Dr Susan Strenk, PhD and Dr Lawrence Strenk, PhD, at the University of Medicine and Dentistry, New Jersey, Piscataway, in collaboration with Prof Koretz.

The studies show unequivocally that the lens rounds during accommodation, the equatorial diameter decreasing by about seven per cent.

This finding is not compatible with the Schachar model, which posits an increase in the equatorial diameter during accommodation, under greater tension from the zonules.

Dr Glasser's group have reported very similar findings in rhesus monkeys to the MRI studies. Other researchers report similar findings in patients with aniridia (Fincham, 1937). They too report a decrease in the equatorial diameter of about six to seven per cent.

"Not a single study has ever shown an increase in equatorial diameter with accommodation; the concept is pure conjecture," Dr Glasser told EuroTimes.

The changes to the lens that lead to presbyopia are more equivocal, however, and resonate with Dr Thornton's long-standing argument that crowding in the anterior segment plays a critical role in presbyopia.

The high-resolution MRI images leave little doubt that the lens continues to grow with age. Better evidence for continued growth of the lens comes from measurements of the wet weight of lenses extracted from human eye bank eyes, which has been reported in many studies. Interestingly, at least in the case of humans, only the anterior portion continues to grow; the equatorial diameter of the lens remains remarkably constant with age, as does the position of the posterior surface (this is not true of rhesus monkeys, whose lens grows in both anterior and posterior portions, fixing the lens in a posterior position).

The anterior growth of the human lens causes an increase in sphericity with age, which drags the ciliary body forwards, restricting the possibility of further anterior movement.

A recent high-resolution MRI-imaging study by Dr Strenk's group ([J Cataract Refractive Surgery 32: 1792-98; November 2006]) shows that, although the lens equatorial diameter does not change with age, the diameter of the ciliary muscle ring certainly does decrease, which might lower zonular tension "ultimately to zero in the non-accommodated state."

"It is far more likely that the ciliary muscle ring is being pulled inward by the zonules. As the lens grows, and its axial thickness increases, this would tend to pull inward on the zonular fibres. In fact, there is substantial evidence that the lens does not become loose with increasing age. A loose lens would result in microfluctuations in the refraction of the eye in older individuals. There is a substantial body of literature on the so-called 'microfluctuations of accommodation' indicating that these are absent in older individuals and that the presbyopic lens is not loose," Dr Glasser noted.

Some have suggested that intracapsular IOL implantation enables the ciliary muscle to revert to a more youthful posterior position. But it is not the IOI implantation per se that accomplishes this, but rather the emptying of the capsular bag of the phakic lens. This in fact suggests that it is the phakic lens and zonular fibres that are pulling the ciliary body inward. After cataract surgery, once the capsule is empty and the capsular bag is flaccid, this allows the release of zonular tension so the ciliary body reverts to its more youthful position, he explained.

This reversion in ciliary muscle position may facilitate anterior IOL movement documented using real-time A-scan ultrasonography by Dr Thornton and others - the basis of the Eyeoneics Crystalens IOL.

In this regard, Dr Strenk cautions: "Lens softening orrelling strategies that don't reduce lens volume or equatoral diameter will not increase circumferential space or restore zonular tension, without which an accommodative lens response is unlikely regardless of the amount of ciliary muscle contraction."

Whether ciliary spherotomzy also increases the diameter of the ciliary muscle ring without tension, and to some degree anterior lens movement, has not yet been examined or proved.

The greater sphericity of the lens with age raises a paradox, known as Brown's Paradox, after Dr Nicholas Brown, MD, Oxford Eye Hospital, UK, who resurrected the use of Scheimpflug photography for studying accommodation and presbyopia in the early 1970s. Using this technique, Dr Brown documented an increase in lens sphericity with age as long ago as 1972.

Greater lens sphericity, in which the unaccommodated state gradually edges towards the accommodated state with age, should obviously lead to myopia rather than presbyopia. The fact is that it doesn't mean there must be compensatory changes in the refractive index of the lens itself; and such changes have indeed been measured, according to Prof Koretz.

"There is an issue of cause-and-effect that has not yet been resolved," Prof Koretz told EuroTimes. "I suspect that the changes in refractive index are secondary to changes in lens growth and sphericity, in other words it's basically atrophy; but that's by no means proved."

All in all, new data, especially high-resolution MRI imaging, seem to confirm the Helmholtz mechanism of accommodation, but there is still plenty of ambivalence about the mechanism of presbyopia. That the lens becomes more spherical with age is beyond doubt; but the role of crowding, zonular tension, anterior IOL movement and the cause of refractive index changes still offer rich veins of enquiry."