The development of modern methods of estimating refraction

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The use of lenses for the correction of refractive errors is of great antiquity, but it is only within the last hundred years that any real progress towards the exact correction of ametropia, can be said to have taken place. The honour of having made the first pair of lenses is possibly to be given to China. Bleached horn seems to have been the material chiefly in use there. Nero is said to have used a precious stone to watch the games in the Circus. Marco Polo, travelling in China in 1270, says that he saw lenses, ground from quartz or semi-precious stones, being used as an aid to sight. So much for tradition, let us betake ourselves to firmer ground.

In 1276, Roger Bacon referred to the possibility of the use of lenses by those who are old and have weak sight. Alessandro Spina, a Dominican friar of Florence, who died in 1313, is usually given credit for the invention of spectacles, though a rival, Salvino D'Armato, may be the correct claimant to the honour. His tomb is in the church of St. Maria Maggiore and the Epitaph runs thus: "Here lies Salvino D'Armato of the Armati of Florence, Inventor of Spectacles, God pardon him his sins. A.D. 1317."

The first reference to spectacles in medical literature appears to be in a work, entitled "Lilium Medicinæ" by Bernard de Gordon, who was a teacher of medicine at Montpellier about the end of the 13th century. The first printed edition was published at Lyons in 1474. The casual manner in which they are mentioned, suggests that they had been known for some time. At the marriage of the Duchess Juta of Austria to Count Louis of Oettingen at Vienna in 1319 one of the guests created considerable excitement by wearing a pair of spectacles which he had received from Salvino D'Armato. The printing of books in very large type during the latter part of the fifteenth and early part of the sixteenth centuries was done expressly for the benefit of readers with hypermetropia—from which apparently a large number of the learned men of that period suffered. As late as 1572, Augustus, Elector of Saxony, desiring to possess a pair of spectacles, dispatched a special messenger, first to Leipzig and then to Augsburg, with orders to get them at the annual fair. Being unsuccessful, in the summer of 1574 he was sent on to Venice; but on arrival

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there he was told that no glasses would be ground before October. Consequently he had to wait on until the optician had them ready. The charge for these was 50 thalers, equivalent to about £50 today.

Though there are numerous references to the use of spectacles in the fifteenth and sixteenth centuries, the medical profession was strongly opposed to their use—Bartisch in 1583 wrote a chapter, on protecting oneself from the need of glasses, and another on ridding oneself of the habit of wearing them. De Saint-Yves described the "three" sorts of vision "the good sight, that of myopes and that of presbytæ" and mentioned the need of spectacles—but he too, has a chapter on "How to be exempted from the use of Spectacles."

Beer of Vienna, writing in the early years of the nineteenth century, attacked, what he called the rage of wearing glasses and the harm they do—he described them as "crutches for the eyes."

The early lenses were made of tourmaline, beryl, quartz, and later of glass. The glass employed was primarily produced in Vienna and subsequently in Germany. The first German frames were made of leather, the bridges being reinforced with fish bones. The first side pieces, if they may be so called, were of string. Metal side-pieces were next introduced. Glasses with frames of iron, brass and copper, were sold in London during the 18th century for 1s. a pair; with gold frames costing from £10 to £20. Tinted glasses were used at the beginning of the Georgian period. Bifocals were the invention of Benjamin Franklin at the end of the 18th century.

James Ware, one of the leading ophthalmic surgeons of the early part of the 19th century, Donders says, is entitled to be described as the discoverer of hypermetropia. In a paper read before the Royal Society in 1812, Ware made some accurate observations—"There are also instances of young persons who have so disproportionate a convexity of the cornea or crystalline, or of both, to the distance of these parts from the retina, that a glass of considerable convexity is required to enable them to see distinctly, not only near objects but also those that are distant; and it is remarkable that the same glass will enable many such persons to see both near and distant objects, thus proving that the defect in their sight, is occasioned solely by too small a convexity in one of the parts above mentioned and that it does not influence the power by which their eyes are adapted to see at distances variously remote. In this respect such persons differ from those who had the crystalline humour removed by an operation since the latter always require a glass to enable them to discern distant objects, different from that which they use to see those that are near."

These observations were forgotten and it was not until 1859, at a
meeting at Heidelberg, that the distinction between hypermetropia and presbyopia was placed on a clear basis by Donders. There was much speculation in the early part of the century as to the nature of asthenopia. Sir William Lawrence spoke of it as an affection of the retina from excessive employment of the eyes, while Tyrrell endeavoured to prove that it was due to congestion of the choroid. Another suggestion was that it was due to application of the eyes to near objects and in consequence some surgeons did tenotomies.

Astigmatism had been discovered, in his own eyes, by Thomas Young in 1793, and later by Airy in 1827, who introduced cylindrical lenses for its correction. That it was due to a difference of curvature of the cornea in the two meridians, was suggested in 1856 by Wharton Jones and Sir William Wilde.

Among the earlier works on ophthalmology of this period, was that of John Cunningham Saunders dated 1816 and a "Synopsis of Diseases of the Eye" by Benjamin Travers—the second edition of which appeared in 1821. In neither of these is there any mention of refraction problems.

Among the ophthalmic works of the third decade is that of William Kitchiner, M.D., entitled "The economy of the Eyes." It was published in 1826. Hints are given for the selection of glasses, preservation of the sight, and the fitting of spectacle frames. Then, curiously enough, it branches off on to the subject of opera glasses and the theatre. Kitchiner says forcing the eyes to work at night, even for a few minutes after they are tired, is of all the eye-spoiling acts the most mischievous—want of mercy in this respect has prematurely ruined the eyes of thousands. Loose, rhetorical statements, devoid of proofs adduced in their support—were dear to the heart of the worthy doctor. To judge from the advice of Doctor Kitchiner the mending of pens was the operation he dreaded most of all, when the preservation of visual acuity was in question; for he writes "mending pens and all operations requiring the sight to be in its best condition, should be attended to early in the day, while the nerves are brisk and before the animal spirits are exhausted and the eyes are fatigued. Kitchiner advises that myopes shall select their own glasses and be content with as low a glass as possible—the visual acuity to be obtained being the ability to see the names on the street corners distinctly and to give a decided outline to objects at 40 feet. Here there is a curious error, for he says that near-sightedness continues in nearly the same degree throughout life and precisely the same glass continues to afford precisely the same assistance. At this time the best double-jointed spectacles with lenses cost £1 1s. and a steel frame with lenses 5s. There are several appendices to this volume, the first by one G. Adams, Optician, the contributor of
a couple of pages on the selection and use of spectacles, when vision is beginning to fail. The matter of the whole book is couched in a flamboyant, unscientific style, but is of interest to us, in that it indicates the way in which the ordering of glasses, was handed over entirely to the optician, whose opinions Kitchener never tires of quoting.

Sir William Lawrence in his work on "Diseases of the Eye," published in 1833—a book which has been described by the late E. Treacher Collins as the best pre-ophthalmoscopic work on ophthalmology, devotes six pages only, out of a total of over seven hundred, to errors of refraction. Two conditions are recognised—myopia in which the rays of light converge too soon, and presbyopia in which the rays are brought to a focus behind the retina. These errors are attributed to conditions in the transparent media. Lawrence speculates as to the reasons for sailors and country people being far-sighted, while students are myopic. He concludes that the probable reason for the smaller proportion of myopes in the lower classes, is the fact that they do not attempt to remedy the defect. The error probably may be confirmed by the habitual use of concave glasses. Nevertheless, Sir William taught that the only method of relieving short sight, was by the use of concave lenses, but they were only to be worn when the eye required particular assistance. The patient was to be allowed to select his own glasses. Farsightedness and presbyopia were regarded as synonymous. Its onset took place as the eye aged, i.e., about 40 to 50 years, and thus it was not clearly demarcated from hypermetropia. Convex lenses were advised for the condition, but only for close work.

The position of refraction at this time on the Continent, does not seem to differ materially from that obtaining in the British Isles.

J. August Franz, Doctor of Medicine and Surgery of the University of Leipsic, was the author of a book on ophthalmology in 1839. The title is imposing "The Eye: A Treatise on the Art of Preserving This Organ in a Healthy Condition and of Improving the Sight" to which is added "A View of the Anatomy and Physiology of the Eye with Observations on its Expression as Indicative of the Character and Emotions of the Mind." Franz recognised myopia and presbyopia only—the former existed when the point of distinct vision at which very small objects could be seen clearly, was nearer to the eye than 15 inches—if the distance was greater than 20 inches presbyopia existed. His view was that weakness of sight in young people is much less common than is supposed—and when they complain of weak eyes the condition is either the first degree of myopia, or is the effect of a temporary pressure of blood towards the head and especially towards the eyes,
and is easily removed, when strict attention is paid to the free circulation of the blood. Whatever shortcomings this theory may have in scientific precision, they seem to be more than counterbalanced by its value as a method of clearing an overcrowded refraction department!

In the management of a case of myopia everything which tends to promote pressure of blood to the head should be avoided. Abstinence from heating drinks, strict attention to diet, washing the eyes with a cold, fresh, spring water, cold compresses to forehead and eyes—not however when overheated, and stimulating foot baths are among the directions to the patient—truly the way of myopes was hard! If anisometropia existed and one eye was myopic, the good eye was to be occluded and the other exercised. Concave lenses were not to be resorted to until absolutely necessary. Franz's remarks on the selection of glasses are worth quoting:

"The person desiring the aid of spectacles will always do well to apply to an experienced and intelligent optician—careful trial is the only sure method of finding good glasses perfectly adapted to the exigency of the case."

In 1840, William Mackenzie of Glasgow produced the third edition of his treatise on the "Diseases of the Eye"—a work which had a reputation, not only in the British Isles, but also on the Continent and in the United States. As with other authors of this period, scant attention is paid to errors of refraction. In the section on the treatment of conical cornea, Mackenzie quotes Sir John Herschel as suggesting being worthy of trial, the procuring of, at any rate temporarily, distinct vision, by applying in contact with the surface of the eye, some transparent animal jelly contained in a spherical capsule of glass: or whether an actual mould of the cornea might not be taken and impressed on some transparent medium. Mackenzie does not suggest the use of glasses for the condition. Although over one hundred pages are devoted to the varieties and treatment of cataract, only three are concerned with the correction after operation, and the information in them is of little value.—"No cataract glasses ought to be given to a patient as long as his vision appears to be improving without them."—He considered, as probably incorrect, the statement that those who were short sighted previous to the formation of the cataract, can, after a successful operation, lay aside their concave glasses and that some may still even require minus lenses. Mackenzie commences the section of his treatise dealing with refractive errors, by defining what he calls "the point of distinct vision"—at which objects are most clearly seen. It averages from 15-20 inches—whereas some eyes cannot see any object distinctly unless it is brought nearer, viz., the myopic eye; others
require the object further away than the average point of distinct vision—viz., the presbyopic eye. He advances sound views to explain the two conditions—he thought the myopic eye must refract too much or be too long and that in the presbyopic eye the reverse obtained. Mackenzie attached great importance to rank as an aetiological factor in myopia—in the inferior stations of society, artificial means for correcting slight defects of this kind are rarely resorted to, and there is even reason to believe that in such people nearsightedness is not infrequently overcome by the increased exertions that are made by the eye to distinguish distant objects. When persons in the higher ranks see their discernment of distant objects is not correct, influenced perhaps by fashion more than necessity, have recourse to a concave glass—the natural consequence is, that their myopia in a short time becomes so confirmed, that the recovering of distant vision is difficult, if not impossible. For treatment he advises using the eyes only on large objects, frequent exercise out of doors, walking and riding into the country and travelling through new and interesting scenes. He utters a strict warning against the use of concave lenses, as being likely to aggravate the disease. For those rash enough to use glasses, he advises double concave lenses, with equal concavity on either side, or concavo-convex lenses, the periscopic lenses of Doctor Wollaston. For the selection of the lenses he taught that the simplest and surest plan was to try a series of them at an optician’s shop. Mackenzie thought that myopia remained stationary throughout life and therefore no change of glasses was necessary and hence the use of stronger lenses was harmful. In spite of his deep rooted prejudice he had a set of concave lenses numbered 1 to 12—number 1 having a focus of 48 inches and number 12, 2\% inches. Presbyopia, or farsightedness, was thought to occur suddenly and at any period of life but the greater number of cases were due to the changes occasioned by advancing years. The refractive powers of the eye were considered to become too feeble, or the optic axis shorter than natural. Among the objective signs, attributable to this cause, were an apparent diminution in the size of the globe, flattening of the cornea, shortening of the axis of the anterior chamber and smallness of the pupil. The onset may be in youth—men of 20 sometimes cannot see to read without a glass of 6 to 8 inches focus.

Mackenzie observed that people who can read as well after 40 years as before, have a little myopia. He is puzzled as to why patients of 80 or 90 years, long accustomed to use strong plus lenses, may recover reading vision—the theories current in his day being: (i) decay of the adipose substance at the bottom of the orbit and the eye lacking its accustomed support, will be
brought by the pressure of the muscles into a kind of oval figure in which state the retina will be moved back to its proper position. (ii) absorption of part of the vitreous, in consequence of which the sides of the sclerotic are pressed inward and the axis of the eye proportionately lengthened. Mackenzie surmised that along with the diminished refraction of presbyopia, there was a loss of accommodative power for near objects. The use of convex lenses was advised for reading but not, as a general rule, for distance. The sudden onset of presbyopia under 40 years of age should make us suspect some derangement of the internal parts of the eye: some pressure behind the eyeball, or some disease of the intracranial portions of the optic apparatus.

The case is quoted of a boy aged 8 years, who suddenly became presbyopic—the disease continued two weeks and was cured by the application of leeches to the temples and purgatives. Two sisters were similarly affected for six weeks. It is interesting to speculate as to the probable diagnosis—perhaps diphtheria is the most likely. Astigmatism, which is called irregular refraction, is mentioned. Mackenzie remarks that irregular formations of the cornea or of the crystalline lens, are probably much more common than is supposed.

We may, I think, fairly infer that the status of the refractionist differed but little in France in the middle of the 19th century, from that in the British Isles. C. Denonvilliers and L. Gosselin published a treatise on eye diseases in 1855. Although it is a comprehensive work, some ten pages only, are given up to anomalies of refraction. These are divided into the usual classification of myopia and presbyopia. The authors’ views in general coincide with the customary teaching of that period, for example, concave glasses were to be used for myopia, but only as little as possible, owing to their tendency to increase this condition. They mention as curative treatment tenotomy of the internal and external recti—a procedure which had the advocacy of several prominent French ophthalmic surgeons but they themselves considered operative interference too risky.

Asthenopia is mentioned—to explain it two theories were put forward—the first that it was a peculiar disposition of the retina to become congested: the second explained it, as a painful compression of the eye, caused by contraction of the ocular muscles. This was thought to take place chiefly on near vision when the muscular contraction, caused the vitreous to press on the retina and thus cause pain. Denonvilliers and Gosselin seem to have inclined towards the retinal theory.

A year previous to the publication of the French oculist’s work, Alfred Smee, surgeon to the Central London Ophthalmic Hospital, had embodied in book form, a series of lectures given at the Hospital.
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Alteration in the axial length of the eye was the only cause Smee recognised for myopia and presbyopia. Far sight almost invariably occurs as a process of natural decay in declining years. The whole eye seems to shrink and the anterior chamber becomes smaller and the cornea flatter. It was then held that the onset of presbyopia was due to absorption of the aqueous, but Smee considered a diminution in the power of adjustment, as he calls it, more common. He regarded hypermetropia as a pathological state, but he had seen cases where it was congenital, the power of adjustment being perfect. Myopia was usually congenital. He observed that labourers and soldiers were not short-sighted and that the literary-minded were affected by the condition and fell into the fallacy of regarding occupation, as being the cause of the absence or presence of myopia. Though not expressly stated, the use of spectacles for the correction of myopia, except when all other methods have failed, did not meet with approval. Irregular vision, as he calls astigmatism, exists in a few cases. It depends on the lens being either of incomplete figure or of its refracting power being abnormal in its various parts. Smee invented an optometer which he suggested should invariably be employed by the optician before supplying spectacles.

John Whitaker Hulke, who was born in 1830, and was one of the surgeons at Moorfields, in some reminiscences of his youth, remarked “in my earliest student days the ophthalmoscope was unknown and errors of refraction were so little understood that a small tortoise-shell case, which could easily be carried in the trousers pocket, containing half-a-dozen convex and concave spherical lenses, was held to comprise a sufficient stock for every trial.”

A few years ago Hasket Derby, one of America’s leading ophthalmic surgeons of the latter part of the 19th century, published a very interesting account of a visit to the clinics of von Graefe, Arlt and Donders in the winter of 1859. He attended the clinical work and “operation” course of Ferdinand Arlt of whose teaching and kindness he speaks most appreciatively. Refraction cases were comparatively rare and were seen by an assistant. Von Graefe’s “Klinik” at Berlin was then visited. The refraction work was done by Liebreich. He used the old Jaeger tests and a case of lenses based on the scale of the Prussian inch—the values being expressed in vulgar fractions.

Students were taught fundus examination on a large rabbit—this animal seems to have been an important part of the teaching equipment to judge from the following story, related by Hasket Derby. One day the rabbit disappeared, a thief, being suspected. It was eventually discovered in the market place where it was identified by Liebreich owing to certain structural peculiarities of
the optic nerve head. Both von Graefe and Liebreich used the inverted image chiefly for fundus examination.

We have now to consider one of the greatest of the many great ophthalmologists of the last century, Cornelius Donders, Professor of Physiology and Ophthalmology in the University of Utrecht. His book "On the Accommodation and Refraction of the Eye" appeared in 1864 in English and produced a revolution in the attitude of the medical profession towards the problems of refraction. The translation was made by William D. Moore, M.D., of 7, South Anne Street, Dublin, and in the preface is a great acknowledgement from the great Dutch scientist, of help on many doubtful points from the Rev. Samuel Haughton, Fellow of Trinity College.

It is a monumental work of over six hundred pages and has been described by H. Friedenwald as one of the ophthalmological writings which deserves to be ranked as a classic. Donders considers the use of test types and recommends those of Dr. Snellen. He himself at first employed Jaeger test types 19 and 20 at 7 or 8 metres, but in 1862 he printed a new set, consisting of letters only. The importance of having a record of the patient's visual acuity is stressed. The refractive condition is to be investigated by the ophthalmoscope, and the power of vision is to be tested by glasses of known focal distance. For this a trial case was used containing:

1. Twenty-eight pairs of biconvex lenses from 2 to 100 inches focal distance.
2. Twenty-eight pairs of biconcave glasses of the same focal length.
3. Twelve prismatic glasses with refracting angles from $30^\circ$ to $180^\circ$.
4. A frame with elastic rings in which to use the glasses.
5. Some pieces of blue glass to hold before the eyes.
6. A glass of carmine red to be used in the case of a false position of one of the visual lines, to colour one of the double images.

Donders was the first to explain clearly the old confusion between hypermetropia and presbyopia. He notes that the range of accommodation in persons who are habitually occupied with close work, is not necessarily diminished, as compared with sailors, agriculturalists and others whose near vision is seldom used for long. It is true, however, that eyes predisposed to myopia are, by much reading and writing, easily rendered more myopic, but these occupations have no influence on the range of accommodation. As causes of a premature diminution of the range of accommodation he gives glaucoma, premature old age, cataract and in...
youth more particularly, paralysis of accommodation. Donders mentions the various forms of lenses which may be used to help the presbyope—bifocals being recommended for occupations, such as school teaching, office work and the like. Sir Joshua Reynolds, he tells us, was in the habit of using such glasses when painting his portraits.

The correction of hypermetropia is well treated. He advises neutralising the manifest hypermetropia and about $\frac{3}{4}$ of the latent. For long while the hypermetropia is still wholly facultative and there are no asthenopic symptoms, he does not give a correction for constant use, but when it has become absolute, glasses are to be worn. In this connection he relates the case of an Englishman, eminent in the scientific world—a hypermetrope—who told Donders that the minerals he was formerly able to see clearly, were now, in a very literal sense, stumbling blocks in his path. The surgeon increased his correction and shortly after, he was the recipient of a letter of thanks from the scientist. "I cannot tell you how grateful I am for the new sense you have given me. I now see the eyes of the handsome girls as well as when I was a young soldier." What better visual acuity could we, even now, desire for our elderly male patients!

He had observed the association between convergent concomitant strabismus and hypermetropia and placed the figure at 77 per cent. A very clear account of the accommodation—convergence factor in the determination of squint is given. Donders was not optimistic as to the possibility of curing myopia—a position from which we have scarcely advanced even now. He says "the more our knowledge of the basis of this anomaly has been established, the more certainly does any expectation in that direction appear to be destroyed, even with respect to the future." He mentions, only to condemn, methods of treatment current in his day; pressure to reduce the increased convexity of the cornea which was thought to be the cause: paracentesis of the anterior chamber, tenotomy of the internal and external recti and removal of the lens. Attention is drawn to a special desk for children called a myopodiorthoticon by which the myope was kept at a long distance from his books: the distance being systematically increased.

The task of the oculist resolved itself into:

1. The prevention of the further development of the myopia, by avoiding strong convergence, by interludes of rest while reading, and by the avoidance of a stooping position.
2. The prescription of suitable glasses.
3. Relieving the asthenopia by glasses or by tenotomy.
4. Combating the secondary disturbances of the myopia.

That Donders recognised the importance of astigmatism as a clinical entity, is shown by the fact that over one hundred pages
are given up to the consideration of the condition. He noted that a certain amount of regular astigmatism occurs in all eyes and considered it abnormal only if the accuracy of vision suffered perceptibly from it. The classification of astigmatism was into congenital and acquired and the influence of the hereditary factor was noted—different children born of the same parents, having the same kind of astigmatic error. Donders makes the observation that when there is a large amount of astigmatism in one eye, with the other emmetropic or nearly so, the upper part of the face is usually asymmetrical also. Slight cases of astigmatism are usually seen first by the ophthalmic surgeon at about 30 years of age, when the range of accommodation is already perceptibly diminished. The various types of astigmatism which we now describe, are clearly differentiated. At first he supposed myopic astigmatism to be rare but later put the figure between 12 per cent. and 13 per cent. Of compound myopic astigmatism he had seen only a few cases—which is difficult to understand. In 1860 an epidemic of diphtheria broke out in the Netherlands. Post-diphtheritic disturbance of vision was then attributed to pathological changes in retinal function. Donders correctly attributed it to paralysis of accommodation. He records the case of a Miss D., aged 26 years, who consulted him on account of failure of vision for near objects. He found that she had dilated pupils, paresis of accommodation and paralysis of the soft palate. She had had an attack of inflammation of the throat five weeks previously. When seen three months later, accommodation had returned and the paralysis of the soft palate was almost gone.

J. Z. Laurence, F.R.C.S., Surgeon to the Ophthalmic Hospital, Southwark, having read Donders' papers "On Anomalies of Refraction and Accommodation" visited Utrecht in 1860. In the preface to his work "On the Optical Defects of the Eye" published in 1865, Laurence expresses the hope that it may serve as an introduction to that book. It is far removed in knowledge and scientific spirit from its immediate predecessors. The sententious moralisings of much of the early nineteenth century ophthalmological literature, are absent and in their room, a new outlook on refractive problems holds sway. He gives a good account of the treatment of myopia—for its measurement he employed an optometer using Jaeger No. 1 type. A warning is given against an over correction, whereby the patient's accommodation is kept constantly at work and also against an under-correction, in which full value is not being derived from the glasses. Incidentally he remarks on the difficulty he had of grasping at first the rationale of action of a concave glass in myopia, but finally arrived at the explanation, that a myopic eye corrected, really sees the virtual images of distant objects at the focal length of the lens but
mentally refers them to their true planes of situation. Laurence remarks on the dazzling effect of which patients complain, when wearing high concave lenses, and thought at first, it was the ocular side of the glass acting as a concave mirror which was at fault. He found that covering this side with black paper and leaving a small central aperture was ineffective. The dazzling was overcome by using a tinted lens and thus he reached the conclusion, that the retina was hyperaesthetic to light. Laurence ordered the same glasses for distance and reading for moderate degrees of myopia with average accommodation, but in higher degrees two pairs. He mentions having seen several cases of apparent myopia, due to a spastic state of the ciliary muscle—yielding to atropine and revealing under cycloplegia, emmetropia, or even hypermetropia, or a lower degree of myopia. He quotes the case, from his practice, of a girl aged 16 years who suffered from asthenopic symptoms who before atropinization, said her vision was improved by a 24 inch concave lens and who, after atropine, required an 18 inch convex lens. It is interesting to note that Laurence recognized that the refraction could be tested by means of cobalt blue glasses before the eyes—on looking at a candle the myopic eye sees the flame as a violet red, surrounded by a blue margin and the hypermetropic eye reddish blue surrounded by a red margin—evidently our duochrome test is not so modern as we might believe. His method of correcting hypermetropia was a matter of trial and error, as retinoscopy had yet to be discovered. In 166 cases of abnormal refraction from his practice 80 were of myopia, 86 of hypermetropia—figures which do not fit in with our refraction percentages. There is a very good account of astigmatism and its treatment. It is interesting to note that a complete set of cylindrical trial lenses was to be had at this time, 1865, manufactured by Murray and Heath of Piccadilly.

A chapter is devoted to asthenopia which is grouped under three causes:

(a) Optical defects of the eye;
(b) Deficient power of the internal recti;
(c) Hyperaesthesia of the retina.

The cause of the first is most frequently hypermetropia, but any optical defect attended with limited power of accommodation, may be to blame.

(b) Is to be detected by the screen test, when one eye will deviate outwards. The relative powers of the muscles are to be tested by means of prisms. Laurence believed weakness of the internal recti was mostly to be seen in myopes but he had observed it in several cases of hypermetropia. For these patients he advised an under-correction. Exercises with prisms base out he
considered of value. Prisms base in have no effect in curing the disease but rather encourage it. In spite of this view, he makes the significant remark that they relieve the asthenopia, by supplementing the action of the internal recti.

As a last resort tenotomy of the external recti is suggested.

(c) Laurence considered cases of hyperaesthesia of the retina to be associated with a low general state of health and advised hygienic measures.

Another ophthalmic surgeon who should be mentioned, is H. H. Walton who published the second edition of his "Treatise on the Surgical diseases of the Eye" in 1861. In it a tribute is paid to Doctor Jacob of Dublin and to Sir William Wilde. It is a book well abreast of the ophthalmological knowledge of the day on most points, but the information on refraction problems is meagre and disappointing.

Conical cornea is considered and the first symptom to arouse attention is short sight. The ophthalmoscope was of value in diagnosis. Walton mentions an instrument made to improve vision—it consisted of two lenses—the one farther from the eye being convex and the nearer biconcave on the principle of telescopic spectacles. Strong concave lenses, he says, sometimes, especially in the early stages, give relief. He mentions that pin-hole apertures may be of value—either without or with a concave lens behind it.

For glasses after cataract extraction a lens 2\(\frac{1}{2}\) inches focus, is necessary for short distances and one of 4 inches focus for distance. He says, "I always admonish my patients never to wear their spectacles except when they are actually wanted and to use their eyes unassisted whenever circumstances will admit, for all out-door pursuits."

With J. Soelberg Wells may be said to begin modern refraction work as we know it. He was the author of two books on the eye—the earlier one "Long, Short and Weak Sight and their Treatment by the scientific use of Spectacles" was published in 1862 and was dedicated to Sir William Bowman. The later work—his "Treatise on the Diseases of the Eye" dedicated to the immortal Albrecht von Graefe, first saw the light of day in 1869. It went through three editions and was translated into German and French. The treatise combined the best features of British and Continental ophthalmology. That Wells had advanced far beyond the stage in which the ophthalmic surgeon sent his patient to the optician to choose his glasses the following extract from "Long, Short and Weak Sight" proves:

"The proper and scientific choice of spectacles is indeed of great importance to the public, and I have no hesitation in saying
that the empirical, haphazard plan of selection generally employed by opticians, is but too frequently attended by the worst consequences, that eyes are often ruined which might by scientific and skilful treatment, have been preserved for years. I would, therefore, strongly recommend the adoption of the following plan which is largely employed on the Continent and also by several ophthalmologists in England. The medical man himself selects the proper glass from his spectacle box (which contains concave and convex glasses the corresponding numbers being kept by the optician) the focal distance of the required glass is written on a slip of paper, which is taken to the optician who supplies the patient with the spectacles prescribed thereon. Thus are we sure that the patient is furnished with the proper glasses."

The problem of the aetiology of myopia gave him food for much thought, as indeed it still does us. Wells had observed that patients suffering from incipient cataract often became slightly myopic, the real explanation was then unknown, but he thought possibly slight swelling of the lens was responsible—quite a shrewd guess! Like Walton he had a device for high myopes, on the lines of our telescopic spectacles—consisting of a small cone of solid glass, the base of which was convex and the opposite surface concave. Presbyopia, hypermetropia and astigmatism are all well described. Wells mentions cases of anisometropia as occurring not infrequently, and the difficulty of treatment, owing to the difference in size of the retinal images after correction. Throughout the whole of the section on refraction the name of Donders appears frequently, giving us an idea of the extent of the debt of modern ophthalmology to the great Dutch scientist.

The story of the growth of refraction need not be carried beyond 1870. Its course since that time is familiar to everyone who practises the science. Following an infancy and childhood, alike stormy and of little repute, it had by 1870 attained, in its manhood, to a high place of honour which the passage of years, has served only to augment. Our ophthalmological ancestors, perhaps, wrought better than they knew, and ours is the privilege of carrying on the work, whose foundations they so truly laid. Of the true refractionist even now, it may be said:—

"With them the seed of Wisdom did I sow,
And with mine own hand laboured it to grow."

BIBLIOGRAPHY


No doubt, all ophthalmologists have had patients whose symptoms were not relieved by wearing ordinary prismatic and spherical lenses. Frequently, the correction of heterophoria, improvement in the co-ordination of the extra-ocular muscles, increased resistance to rapid fatigue of the extra- and intra-ocular neuro-muscular mechanism, or training which is designed to augment the flexibility between convergence, divergence, and accommodation, also fail to produce the desired results. The improvement of lighting conditions, especially protecting the eyes from glare, and the treatment of local chronic inflammatory diseases of the conjunctiva and eyelids are not always effective.

If we admit that there may be cases which we cannot relieve by the methods we ordinarily employ, are there other possible factors which may be considered? Aniseikonia is definitely known to be one of these factors but further scientific study is necessary before all the possible clinical applications can be determined.

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THE DEVELOPMENT OF MODERN METHODS OF ESTIMATING REFRACTION

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