Historical summary of visual fields methods

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ABSTRACT — A brief historical progression of visual field testing is presented. The time period is from ancients who had no instrumentation to moderns who employ sophisticated diagnostic methods.

KEY WORDS — visual field defects, scotoma, perimeter, Bjerrum technique, history of visual fields

Our ancestors probably suffered from the same afflictions as we of modern times, including visual field defects. What has changed, however, is our ability to test and interpret these problems. A brief sketch of the progress of this ability is presented.

The ancients

Greenblatt, an endocrinologist, made an interesting speculation from biblical interpretation that David may have discovered that Goliath had constricted visual fields. (It is now well known that giantism may be associated with pituitary tumors which, in turn, may lead to visual field defects, often hemianoptic and bitemporal.) Greenblatt wrote of the David and Goliath encounter: "Then as his adversary hesitated clumsily turning his head to bring back the youth within his limited field of vision, and the philistine (*sic*) came on and drew near unto David . . . and that David won his victory by superior knowledge, skill, and ability rather than by brute force."[1]

The first clinical investigation of visual field defects is generally accredited to Hippocrates in the fifth century B.C. His recognition and study of these defects must have derived from subjective reports of perceptive patients, many of whom complained of half-blindness. This may have been the first time hemianopsias were described and reported in the literature. Although hemianoptic defects were studied later by others, it was not until 1856 A.D. (over two thousand years later) that the astute von Graefe established the differentiation between homonymous (uncrossed) and heteronymous (crossed) hemianopsias.[2]

Ptolemy, in 150 A.D., is the first known to have used perimetric instrumentation to measure the extent of the visual field; however, the exact nature of the equipment used in his experiments has not been left in the historical record. For reasons unknown, he believed the width of the normal visual field to be an exact right angle.[3] This misconception of Ptolemy could possibly have been due to the ancients' theory that "pneuma," conducted by the optic nerve and media, streamed outward from the lens in a 90° angle in a visual conic form.

It was finally in 1604 that Kepler explained the principle of the physics of sight in terms of an inverted retinal image.[4] This set the stage for modern investigation of the visual field.

Limits of the visual field

Probably the first illustration of the limits of the field of vision was in 1602 by Ulmus of Padua.[5] Anatomical obstructions such as hair and nose that limited peripheral vision, were taken into account. Thus, the concept of relative and absolute visual fields were realized.

Young,[6] in 1801, made the first reliable observations on the area of the visual field of an eye. The extent of vision when using a luminous test object was: "upwards it extends to 50°, inwards to 60°, downwards to 70°, and outwards to 90°." (These are close to present-day standards.)

Scotomas

The physiological blind spot is said to have been discovered by Mariotte in 1666. Malbran[7] related a short story about Mariotte's discovery. Apparently, Mariotte once told a friend that he had found the normal blind spot of the visual field and wished to demonstrate this to the king. The friend admonished Mariotte that he must be pretty sure of the results; otherwise, there may be decapitation. As it turned out, Mariotte was able to demonstrate his new discovery by asking the king to look at a sidewise fixation point and showed that the head of *another* person, 20 feet away, became invisible.

The revelation of this scotoma stimulated widespread interest in testing for pathological scotomas. Two schools of thought evolved to explain scotomas — opacities in the media versus retinal lesions. This conflict of thought continued until the early 1850s with the introduction of the ophthalmoscope. This technological innovation allowed either etiology to have a possible valid explanation. However, it emphatically demonstrated how projection of retinal lesions onto the visual field are in accord with Kepler's principle of the physics of sight.

The arc perimeter

Visual fields were almost exclusively plotted on flat surfaces (campimetry) up until 1869. It was in this year that the invention of the perimeter is credited to Foerster.[8] Various, but effective, devices were used until then. For instance, von Graefe used any convenient flat surface such as a table top, piece of paper, or a chalkboard. For the next 20 years following the introduction of Foerster's perimeter, the popularity of the perimeter flourished, resulting in many embellishments and continuing developments.

The hemispherical perimeter, closely resembling those "salad bowl" perimeters of the present, was devised by Scherk in 1872.[9] In order to provide good illumination to the inside of the spherical shell, half of the shell could be swung back out of the way on a hinge at the zero point. Interestingly, the fixation point, as in perimeters up to this time, was either to the right or the left by 15 degrees so that the zero point coincided with the blind spot. This was so the record chart would show the blind spot at zero (supposedly to harmonize the concept at the time that the optic disc was the zero reference point).

Emphasis changes

Testing procedures with the campimeter went through several changes before refinement was achieved. Mariotte, for example, would perform testing at a relatively great distance, e.g., several meters (a modern-day refinement we could find useful). However, the distance shrank in the mid-1800s and remained small (e.g., 33cm) until the introduction of Bjerrum's technique in 1889. Bjerrum revived the long-term testing technique with fixation distances of one to two meters.

The advantages of the greater sensitivity in detecting central and paracentral scotomas over the previously used short-range campimeters seems to have been obvious to conscientious practitioners, based on the rapid rise in the popularity of the tangent screen. It is interesting to note that some of the relatively new campimeters have short fixation distances of 1/3 meter, e.g., Harrington-Flocks Visual Field Screener[10] and Friedmann Visual Field Analyzer.[11]

The tangent screen technique of Bjerrum was simply a "matte-black hanging covering the entire wall of the room" and "the essentials of the technique were the small test-object and the long range at which he worked. . . ."[12] Many followers of Bjerrum introduced various types of tangent screens, but his basic principles were the same in each instance. Thus, it is not hard to imagine why the tangent screen used in visual fields testing today is referred to as the Bjerrum screen; although it was Bjerrum's technique, and not his equipment, that was the epochal breakthrough.

According to Lloyd,[13] there was an . . . "earlier stampede from the campimeter to the perimeter" when the perimeter was introduced in 1869 and later a . . . "mass rush from the perimeter to the campimeter . . ." after 1889 when Bjerrum's technique took hold.

Unfortunately, during the 20-year hiatus when the perimeter reigned, much of what had been learned about paracentral and central field defects was lost due to the relative insensitivity of the perimeter as compared with long-range campimeter testing. Fortunately, however, the technique of Bjerrum received widespread acceptance in the ophthalmic community. The tangent screen was practically unchallenged by the perimeter until the late 1960s. Many revived embellishments for the arc perimeter were marketed, but it was the modern hemispherical perimeter that caused changes in attitudes.

Hemispherical perimeter

The perimeter, such as that of Goldmann, has become the "standard" with which other visual field instruments are compared. This judgment may be on a theoretical basis rather than on clinical empirical evidence; because, the majority of practitioners currently use means other than the hemispherical perimeter when clinically testing fields on a routine basis. Although it is likely that the use of the hemispherical perimeter will increase in the future because of some of the advantages it offers.

The chief advantage is that close-to-identical physical testing conditions can be repeated upon subsequent visits. Theoretically at least, the exacerbation or remission of a patient's visual field defect can be charted in a more valid manner than if conventional methods are used. Light intensity of the test spot can be duplicated as well as background luminance, from visit-to-visit. Furthermore, the luminances of the spot and background remain constant throughout the field. Another advantage is that "light-sense" or *static* perimetry can be performed with such instruments.

There are several disadvantages when testing with the hemispherical perimeter. First of all, static perimetry is so time consuming that very few practitioners employ this with any significant frequency. (It would take hundreds of hours to completely cover the visual field with static testing.) Most clinicians continue to use *kinetic* testing because of the relative quickness in testing the entire field. A disadvantage I find, even with kinetic testing, with an instrument such as the Goldmann perimeter is that the examiner and examinee are separated by the shell with the examiner's having to communicate with the patient while peeking through a "peephole."

As to the Bjerrum screen, great consistency in visual field results have been found in charts I've examined over long periods. This is particularly true when the patient returns to see the same doctor in the same room. Bertram Roberts and I examined the records of many patients who had visual field defects and were tested by various optometrists in a large health maintenance organization. Surprisingly, there was great consistency in the field chartings of the tangent screen, notwithstanding the vagaries of luminance variation of such a test. Therefore, I am not convinced that the reliability of the hemispherical perimeter vitiates the validity of traditional tangent screen techniques.

The particular hemispherical perimeter that will probably become very popular is the automatic *screener*, e.g., Fieldmaster. Elmstrom[14] stated that this type of visual fields screening instrument "... is now receiving relatively wide acceptance in the optometric and ophthalmological professions." With such a method, the doctor's time can be spared by having a technician administer the visual field *screening*. The fact that the importance of having a "fields" on every patient is being realized together with the time-saving advantage, probably explains the popularity of such instruments.

Other considerations

By combining the results of the VEP, ERG, and EOG with visual fields chartings, the clinician is aided in making a correct diagnosis. Other clinical testing, such as photostress, color perception, Amsler grid, OKN and pupillary reflexes can aid in differential diagnosis.[15]

My opinion is that the expertise of the perimetrist will continue to be of greater importance than any piece of equipment used for testing of the visual fields (as in David's encounter with Goliath). I hope the future of the development of visual fields methods will be as productive and exciting as the past. **AOA**

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