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The first signs of glaucomatous cupping in the optic nerve

Pierwsze objawy uszkodzenia jaskrowego w nerwie wzrokowym

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Summary: Evaluation of the optic disc is important for both the diagnosis of glaucoma, and in monitoring the progress of glaucoma. Along with visual field examination, it allows the presence of glaucoma to be recognized, and for progressive damage to be seen. Glaucoma can occur despite intraocular pressure (IOP) in the normal range, but as importantly, can be absent even when the IOP is distinctly high.

Słowa kluczowe: jaskra przewlekła, jaskra pierwotna otwartego kąta, badanie kliniczne tarczy nerwu wzrokowego, wnęka nerwu wzrokowego, zagłębienie nerwu wzrokowego, wnęka tarczy, zagłębienie tarczy, zasada ISNT.

Key words: chronic glaucoma, primary open-angle glaucoma, clinical examination of the optic disc, optic nerve cupping, optic nerve excavation, optic disc cupping, optic disc excavation, ISNT rule.

Introduction

What an honor to receive the Tadeusz Krwawicz medal in his memory at a meeting of the World Ophthalmology Congress and secondly to be invited to Poland to give a memorial lecture to the Polish Ophthalmological Society. Now, I am honored by you a third time by your asking me afterwards to provide a manuscript of my lecture that can be published. I apologize that it has taken me almost so long to provide the manuscript soon after it was requested. After all your kindness to me, it is shameful that I could not do it sooner.

In this manuscript, based on the lecture delivered in 2008, attention will be paid specifically to the recognition of glaucomatous damage to the optic nerve when it is first beginning, so that a diagnosis can be made in the early stages of the disease and treatment started early. Emphasis is on detailed evaluation of the neuro-retinal rim of the optic disc, with less attention to the excavation, which supplements evaluation of the rim.

Methods to examine the optic disc

Binocular indirect ophthalmoscopy has been an important advance in evaluation of the fundus, but has serious limitations for evaluation of the optic disc for glaucoma. The light intensity is such that areas of retinal pigment epithelial atrophy ("zone beta") around the disc can be taken to be part of the optic disc substance, thus underestimating the loss of neuro-retinal rim and its reduced width. In turn, the extent of excavation (cupping) is underestimated. In addition, with binocular indirect ophthalmoscopy, pale nerve substance can appear to have a healthy color because of a red glow from the capillary bed behind the eye, so that a cupped region of the disc may appear quite healthy. Secondly, the wide field of view means that the optic disc is not well magnified, and the details of the optic disc structure are often not obvious. Finally, the stereoscopic features are less often seen for optical reasons, because the depth magnification is the square of the lateral magnification, which is necessarily reduced in order to obtain a wide field of view. The details of depth and topography are diminished compared to the view when the disc is seen at greater magnification. The infrequently used +14 diopter lens offers considerable improvement in magnification and depth magnification, but more often an examiner uses the standard +20 diopter or +30 diopter lens with the binocular indirect ophthalmoscope to examine the fundus and will fail to observe even advanced cupping of the optic nerve.

Often a person skilled with direct ophthalmoscopy can recognize the 3-dimensional features of the optic disc and its margin in the magnified view, but much better is to examine the optic disc with both magnification and stereopsis. This is accomplished with a biomicroscope and a high power (for example +78 or +90 diopter) lens, or even better a Hruby lens of -55 diopter power, or a Goldmann contact fundus lens. An advantage of these last two are that the magnification is greater with a low power (whether positive or negative) lens, and the axial magnification (depth) is greater according to the square of the lateral magnification. The higher power +78 or +90 diopter lenses act as reverse telescopes, and unfortunately reduce magnification, so the lower power Hruby lens or Goldmann contact lens offer better lateral and much better depth magnification. Additional magnification provided by the biomicroscope of the slit lamp will improve the lateral and axial magnification. A disadvantage of the Goldmann lens is the need for topical anesthetic and lubricant drops, which may compromise the

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quality of a photograph obtained after the examination, but usually gives the best view.

Another advantage of the biomicroscopic examination is the use of a slit beam illumination instead of diffuse illumination. The slit beam is not used in the manner used for the anterior segment, that is, to view an optical cross section from the side. Instead, a very thin slit beam is best used by directing it along the axis of view. The beam provides a line on the surface of the retina and disc tissue, which can be viewed stereoscopically. It provides an opportunity to see the contour of the surface. Few ophthalmologists are aware of this valuable feature of using a biomicroscope with a slit beam illumination.

Stereoscopic fundus photography is valuable as a means to record the state of the disc, so that in the future, if there is suspicion of a change, a second photograph can be obtained and compared to the original. It has an advantage of being able to examine the details of the disc at leisure without eye movement, which may prove of particular value for some patients, and the ability to recognize small changes over time. It does, however, lack the advantages of a thin slit illumination that can be moved across the disc surface to get a complete evaluation of the disc surface. Photographs are necessarily used for a manuscript such as this, and as a record of the disc appearance in the medical record for future comparison, but for initial diagnosis is somewhat less satisfactory than a direct stereoscopic view with slit-beam illumination.

The Normal Optic Nerve Head

It is always good to know the structure of the normal optic nerve (or any anatomic structure) and particularly its natural variations, so that abnormalities caused by disease can be recognized when they are present. The optic nerve head is a three dimensional structure, which when viewed by fundus examination is called the optic disc. It is the location where axons from the inner retinal nerve fiber layer come together, turn in order to exit the eye, become myelinated, and form the orbital portion of the optic nerve, the anatomic details of which have been summarized (1). For axons to exit, there is a hole, recently named the "neural canal" (2), through the outer retinal layers, the choroid, and the sclera. The boundaries of the opening in the various tissue layers ideally are accurately aligned, but usually are imperfectly aligned so that various pigmented and non-pigmented boundaries mark the location of the exit of the nerve fibers.

Figure 1 shows the appearance of the prototype typical normal optic disc. Several features are to be noted and remembered. In order not to cover the macula, the nerve fibers from the temporal retina arc around the macula and thus form a thicker bundle as they approach the optic disc in the superior and inferior quadrants. They occupy a greater area in the neural canal in these two sectors than the fibers from other regions of the retina. Thus, the opening (neural canal) is typically a little taller than it is wide, but when the upper and lower sectors are filled in with a larger number of nerve fibers, the remaining space (the "cup") is round, even though the optic disc itself is vertically oval. Very properly, attention should be paid not to the cup as much as to the neural rim. The area occupied by exiting nerve fibers is greater in the inferior and superior sectors than in the nasal and temporal sectors (Fig. 2). The inferior surface of the cup is often sloped, especially toward the temporal side, so that the apparent width of the neuro-retinal rim is somewhat greater inferiorly than superiorly. They may

Fig. 1. Prototype normal optic disc.
Ryc. 1. Wzorcowa prawidłowa tarcza nerwu wzrokowego.

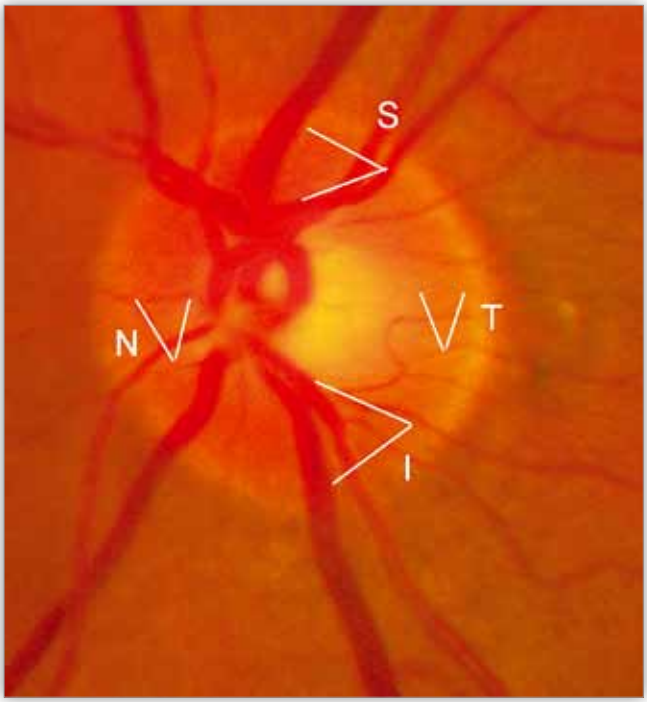

Fig. 2. Another normal optic disc in which is indicated that the width of the neuro-retinal rim is somewhat greater inferiorly and superiorly, and both are wider than in the nasal sector, with the width in the temporal sector being the least.
Ryc. 2. Kolejna prawidłowa tarcza n. wzrokowego, na której zaznaczono, że szerokość rąbka nerwowo-siatkówkowego jest nieco większa od dołu i góry, przy czym szerokości te są większe niż w sektorze nosowym, a szerokość części skroniowej jest najmniejsza.

be nearly equal, however, and the importance is that both are greater than (or at least no less than), the area of exiting tissue nasally, which in turn is greater than the small amount of tissue exiting in the temporal sector, because the fibers in the papillomacular bundle are both smaller and fewer. This leads to the rule that in a completely normal disc, the width of tissue seen as it leaves the eye should be, from greatest to least, in the sequence Inferior, Superior, Nasal, Temporal (ISNT rule) (3).

When applying this rule, it is important to consider carefully where is the boundary of the neural canal. The arrows in figure 3 indicate the boundary of the neural canal, now known to represent the termination of Bruch's membrane, usually covering the collagenous flange of sclera that Elschnig called "border tissue". The opening in Bruch's membrane is the smallest opening through which the axons must pass to exit the eye. Any judgement about the width of the neural tissue in any meridian is made by considering the distance from this boundary to the boundary of the cup. It is recognized in most discs as the inner boundary of a white stripe that surrounds the disc, although it may be obscured in places around of the circumference of the disc by thick overlying axon bundles or by pigment layers. It is easily seen in most discs for much of the circumference, and its position extrapolated by the observer in the sectors where it is not easily seen.

The boundary of the cup is more difficult to define, because the irregular conical shape of the excavation makes the diameter arbitrary in meridians where the wall of the cup is sloping, so that the size of the cup depends on the plane at which you choose to designate the boundary on the sloping wall of the cup (Fig. 4).

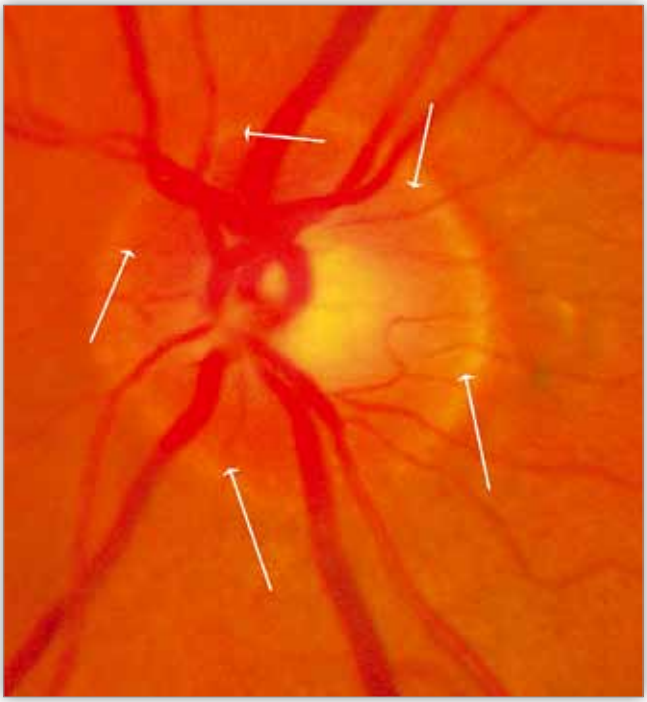

Fig. 3. Boundary of the neural canal. The width of the neuro-retinal rim is measured from the inner side of a white ring around the disc, which is sometimes subtle or partially hidden, so its position must be estimated from portions that are visible. The location is shown here at the end of the white arrows.

Ryc. 3. Granice kanału nerwowego. Szerokość rąbka nerwowo-siatkówkowego jest mierzona od wewnętrznej strony białego pierścienia wokół tarczy, który miejscami jest niewyraźny lub częściowo zakryty tak, że jego pozycja musi być oszacowana na podstawie widocznych fragmentów. Lokalizacja pierścienia oznaczona jest końcami białych strzałek.

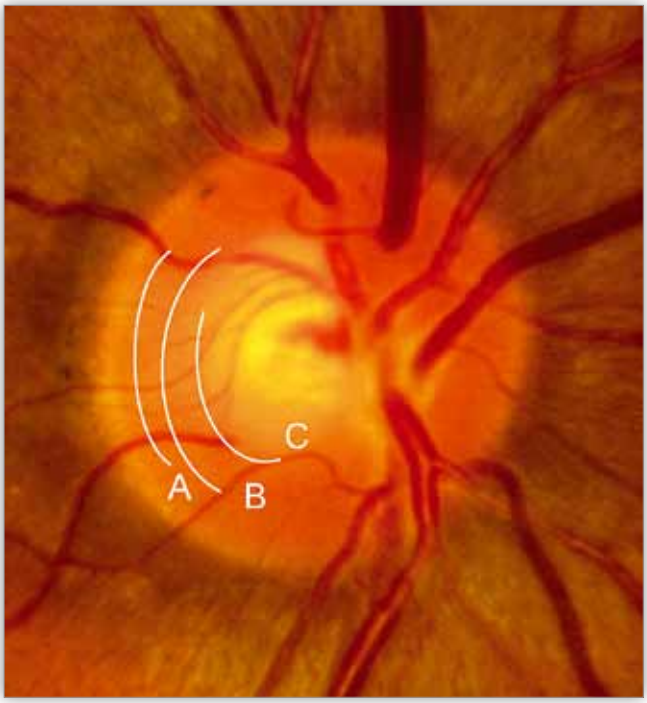

Fig. 4. Sloping sides of the cup, especially in lower temporal region. The cup boundary is arbitrary, sometimes indicated at the level of the retinal surface (A), sometimes in the middle of the sloping slide, extrapolating from the boundary indicated by a non-sloped portion in the upper nasal quadrant (B), and sometimes taken to be the bottom of the excavation (C).

Ryc. 4. Pochylone ściany zagłębienia (wnęki), szczególnie w części dolnej skroniowej. Granice wnęki są arbitralne, czasami pokazane na poziomie powierzchni siatkówki (A), czasami w środku pochyłej ściany, ekstrapolowane z granic wskazanych w niepochylonej części w kwadrancie górnym nosowym (B), a czasami brane z dna zagłębienia.

However, if the criterion for normalcy is based on comparing the four sectors to determine whether the ISNT rule is satisfied, it becomes a little less relevant to be exact about the location of the mythical cup margin, an effort to define the edge of a 3-dimensional structure in a 2-dimensional representation (Fig. 5).

In larger discs, the neural canal is larger than needed for the usual normal number of nerve fibers, in which case the excavation (representing the unused portion of the neural canal) is larger, producing a physiologic excavation, which sometimes can be quite large. Often the disc itself is less obviously oval, but seems round. Yet, in most cases, the ISNT rule is satisfied if one looks closely at the width of the neural rim in the four primary meridians (Fig. 6). Looking only at the rim, and not at the cup, it can be seen that the rim has a somewhat greater width superiorly and inferiorly than nasally, and is the smallest temporally.

When the exit of the nerve bundles is oblique, the disc appears "tilted". The inner wall of the sloping cup wall is seen instead of the width of the exiting nerve tissue. It such cases it is necessary not to take the width of the neural rim as seen through the pupil, but to make a mental transformation of what

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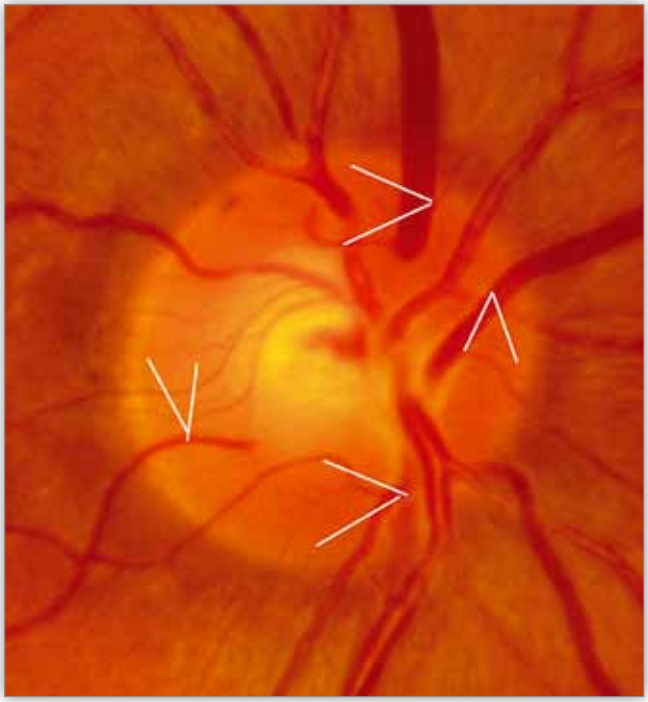

Fig. 5. Same disc as figure 4. Despite the irregular conical shape of the excavation, the neuro-retinal rim can be judged to be most abundant inferiorly and superiorly than to the nasal and temporal sides.

Ryc. 5. Ta sama tarcza co na rycinie 4. Pomimo nieregularnego stożkowatego kształtu zagłębienia można oszacować, że rąbek nerwowo-siatkówkowy jest większy od dołu i góry niż od stron nosowej i skroniowej.

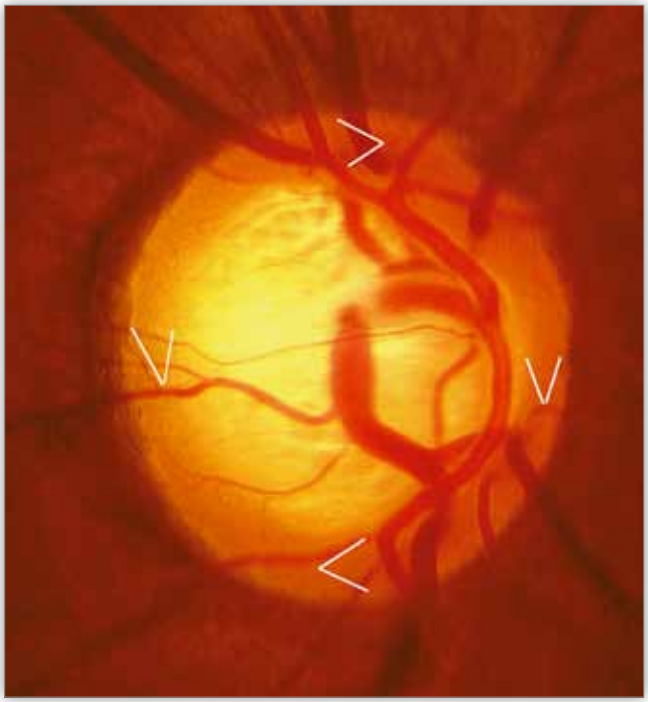

Fig. 6. Large disc with a large cup. The ISNT rule is followed, with neuro-retinal tissue just as abundant above and below as it is to the sides.

Ryc. 6. Duża tarcza z dużą wnęką. Reguła ISNT jest zachowana, a rąbek nerwowo-siatkówkowy tak samo obfity od dołu i góry jak po bokach.

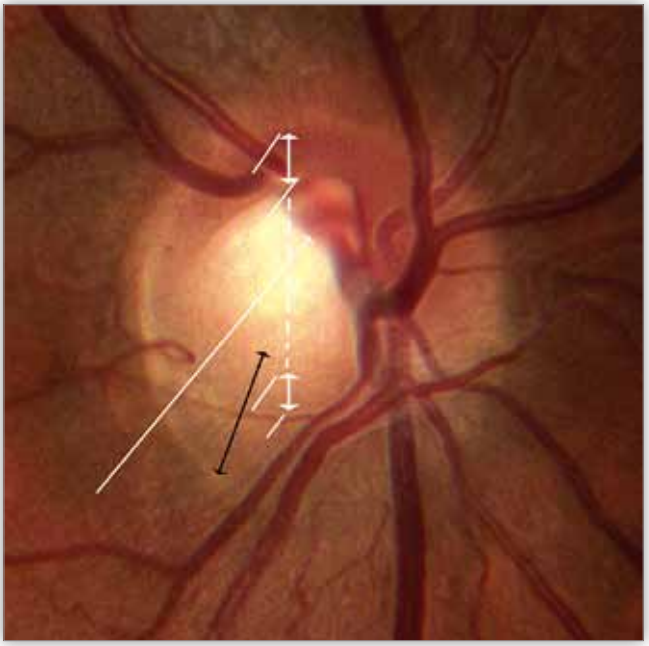

Fig. 7. Oblique exit of the optic nerve, producing a tilted view of the optic disc. Inferiorly, the thickness of the neuro-retinal tissue (double white arrows) is difficult to judge, as it is viewed from the surface of the cup, and the thickness of interest is perpendicular to the axis of the exiting nerve. Optic nerve damage is gauged by the thickness of the nerve fibers that form the wall of the cup (double white arrows), which is difficult to do clinically. As nerve fibers are lost, the neuro-retinal tissue may become more pale, but the cup does not seem to enlarge in an ophthalmoscopic view. The health of the nerve should not be judged as the apparent width (double black arrow), which represents the depth of the cup and not the thickness of the neuro-retinal tissue.

Ryc. 7. Skośne wyjście nerwu wzrokowego daje obraz pochylonej tarczy. Od dołu grubość tkanki neuroretinalnej (podwójna biała strzałka) jest trudna do oceny, ponieważ jest widziana z powierzchni wnęki, a tkanka ułożona jest prostopadle do wychodzącego nerwu. Uszkodzenie nerwu ocenia się na podstawie grubości włókien nerwowych, które tworzą ścianę wnęki (podwójne białe strzałki), co jest klinicznie trudne. W miarę utraty włókien nerwowych tkanka neuroretinalna może stawać się bledsza, ale wnęka nie wydaje się powiększona w badaniu oftalmoskopowym. Stan nerwu wzrokowego nie powinien być oceniany na podstawie domniemanej szerokości, odpowiada ona bowiem głębokości wnęki, a nie grubości tkanki nerwowo-siatkówkowej.

the cross-sectional width of the neural tissue in each sector as if viewed as a cross-section of the layer of tissue lining the inside of the oblique cylindrical canal. Not only is the three-dimensional anatomy of such discs difficult to visualize, but it is difficult to evaluate the quantity of exiting axons along sloped exit canals (Fig. 7, 8), which is important in evaluating whether there is glaucomatous damage to the disc (see below), which is based on comparing the quantity of axons in various sectors around the disc. At times the nerve fibers may be spread out over a tilted wall of the exit neural canal if it is shaped like a funnel entering the cylindrical canal, in which case it may be impossible to decide whether a thinner lining of neural tissue over a broader area may contain an equivalent amount of tissue as elsewhere around the rim. This judgement is most commonly difficult in the lower temporal region of larger discs that exit obliquely in the superior and nasal direction.

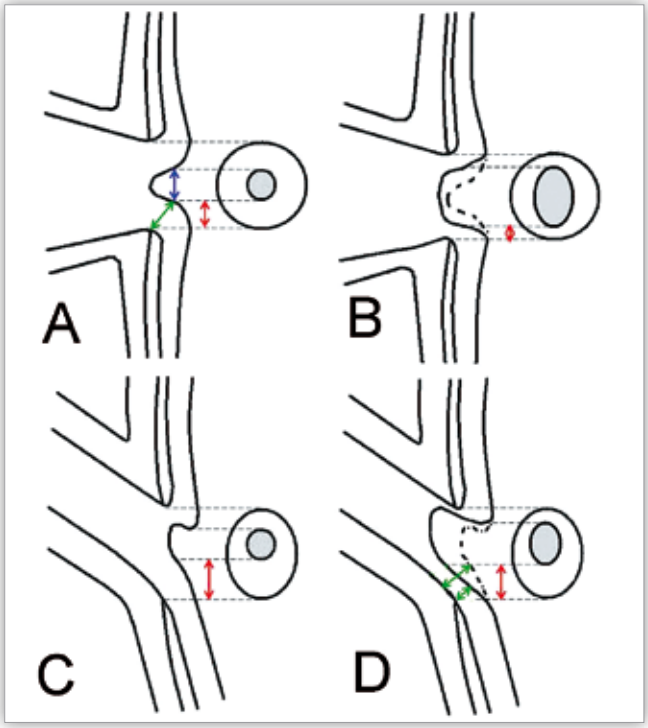

Fig. 8. Diagram of effect of tissue loss of a non-oblique exit and an oblique exit of the type shown in figure 7. In a non-oblique exit, the healthy nerve (A) shows a moderate cup (blue arrow) with a heathy thickness of nerve fibers (green arrow) and moderate width of the neuro-retinal rim on ophthalmoscopic view (red arrow). In B, the cup has enlarged (dotted line represents position of disc surface before glaucomatous loss of tissue), and the neuro-retinal rim has become narrower, illustrated here in the vertical plane. In panel C, a healthy nerve with an oblique exit produces an oblique view of the nerve fibers inferiorly where there is a sloped wall of the cup, which appears wider than superiorly. With loss of nerve fibers (D), the nerve fiber layer is thinner (green arrows), but the width in the ophthalmoscopic view of the sloped inferior wall of the disc is affected very little.

Ryc. 8. Diagram pokazujący rezultat utraty tkanki przy prawidłowym oraz skośnym ujściu nerwu, jaki pokazano na rycinie 7. Przy prawidłowym (nieskośnym) ujściu (A) zdrowy nerw wykazuje umiarkowaną wnękę (niebieska strzałka) z prawidłową grubością włókien nerwowych (zielona strzałka) i średnią szerokość rąbka w rzucie oftalmoskopowym (czerwona strzałka). W części B wnęka jest powiększona (linia przerywana pokazuje pozycję dna tarczy przed utratą tkanki z powodu jaskry). W części C skośne ujście zdrowego nerwu powoduje, że włókna nerwowe od dołu, gdzie ściana wnęki jest pochylona, widoczne są ukośnie i wydają się szersze niż u góry. Podczas utraty włókien nerwowych (D) ich warstwa staje się cieńsza (zielone strzałki), ale jej szerokość w rzucie oftalmoskopowym pochyłej dolnej ściany tarczy jest tylko minimalnie zmieniona.

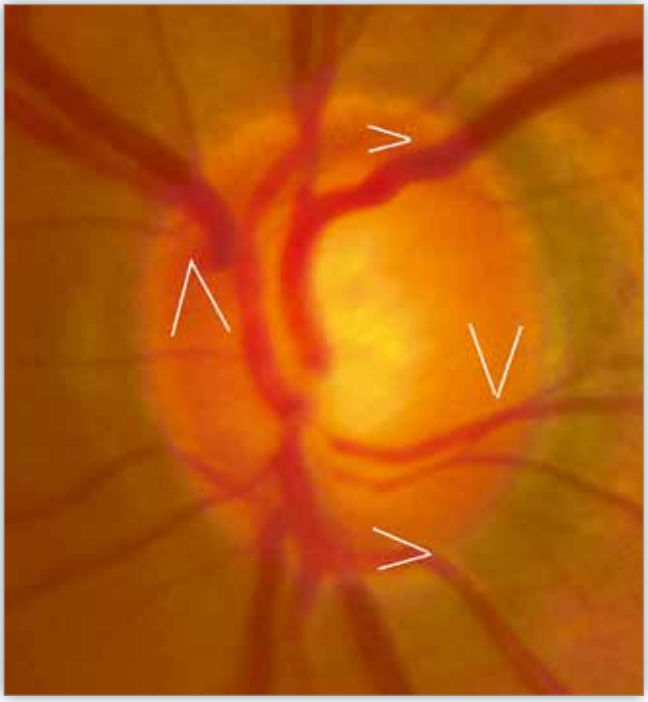

Fig. 9. Moderate glaucomatous cupping. As shown by the white brackets, the neuro-retinal rim is wider nasally and temporally than it is inferiorly and superiorly, opposite from the relative widths of the rim in health discs according to the ISNT rule.

Ryc. 9. Umiarkowane zagłębienie jaskrowe. Białe nawiasy wskazują, że rąbek nerwowo-siatkówkowy jest szerszy od nosa i skroni niż od dołu i góry, przeciwnie do względnych szerokości rąbka w zdrowych tarczach zgodnie z regułą ISNT.

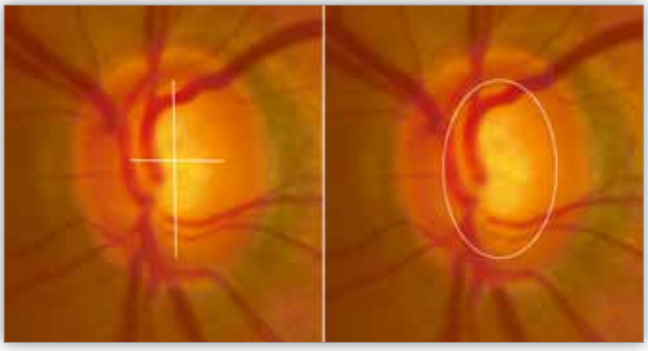

Fig. 10. Same disc as figure 9, to show (left panel) that the cup is taller than it is wide, and (right panel) that the cup has an oval shape vertically oriented.

Ryc. 10. Ta sama tarcza co na rycinie 9. pokazuje (po lewej), że zagłębienie jest większe pionowo niż poziomo i ma kształt owalny skierowany do góry (po prawej).

Glaucoma

When glaucoma starts to affect the optic nerve, at first there may be a diffuse loss of axons, so that the neural rim becomes slightly narrower in all meridians, and there is a general enlargement of the excavation. It is difficult to detect glaucoma at this stage.

However, before long there is nearly always a greater loss of axons in some axon bundles than in others. Often this is most conspicuous in the two arcuate regions (where the nerve fiber layer is thicker to begin with), than elsewhere (4,5). As a result, the neural rim becomes thinner superiorly and inferiorly. This is shown in figure 9, and the ISNT rule or normal discs does not hold. At the same time, of course the cup is taller than it is wide, and the excavation becomes ovoid with the major axis vertical (Fig. 10), instead of round as in the normal disc (Fig. 1). This is the most reliable sign of early glaucomatous damage, and is easily seen in discs that are of normal size and not tilted, as in this first example shown. Other examples are shown in figures 11 through 13. Figures 14 and 15 illustrate the importance of looking at the width of the rim as the primary criterion, as the cup may not be obviously oval.

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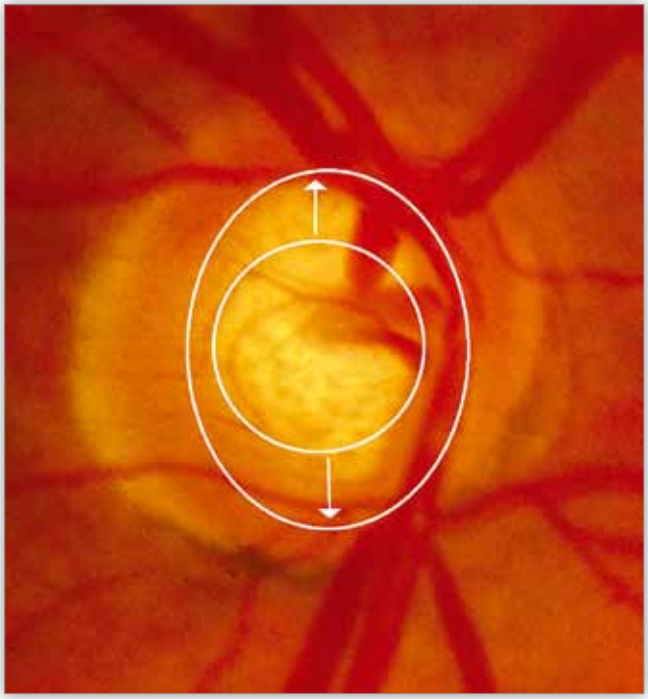

Fig. 11. Glaucomatous disc in which the cup has enlarged from is presumed previous size in all directions, but preferentially in the vertical direction to produce a vertically oval cup.
Ryc. 11. Tarcza jaskrowa, w której wnęka powiększyła się od domniemanego pierwotnego rozmiaru we wszystkich kierunkach, ale szczególnie do dołu i góry, dając pionowe owalne zagłębienie.

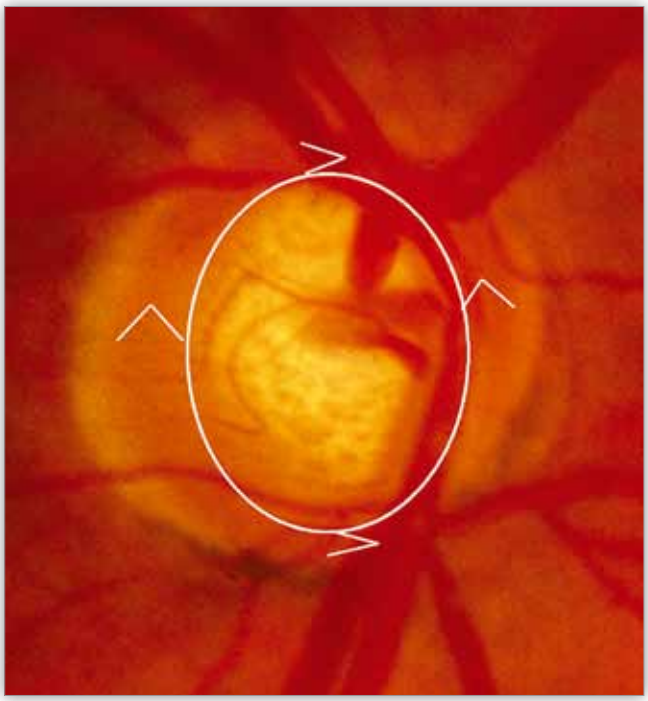

Fig. 12. Same disc as figure 11, to show how the preferential loss of tissue in the vertical meridian makes the neuro-retinal rim narrower superiorly and inferiorly than in the other sectors.
Ryc. 12. Ta sama tarcza co na rycinie 11. pokazuje, że preferencyjna utrata tkanki w południku pionowym powoduje, że rąbek jest węższy do góry i dołu niż w pozostałych sektorach.

It is sometimes difficult at first to recognize early glaucoma in some discs. Figure 7, and maybe figure 5, are normal discs

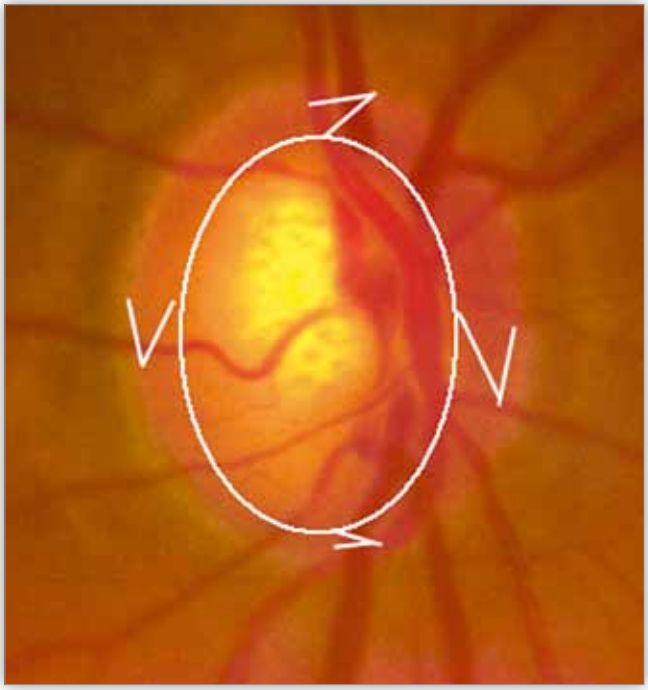

Fig. 13. Another example of vertically expanded cup with narrow neuro--retinal rim in the vertical sectors.
Ryc. 13. Inny przykład pionowo powiększonej tarczy z wąskim rąbkiem w sektorach pionowych.

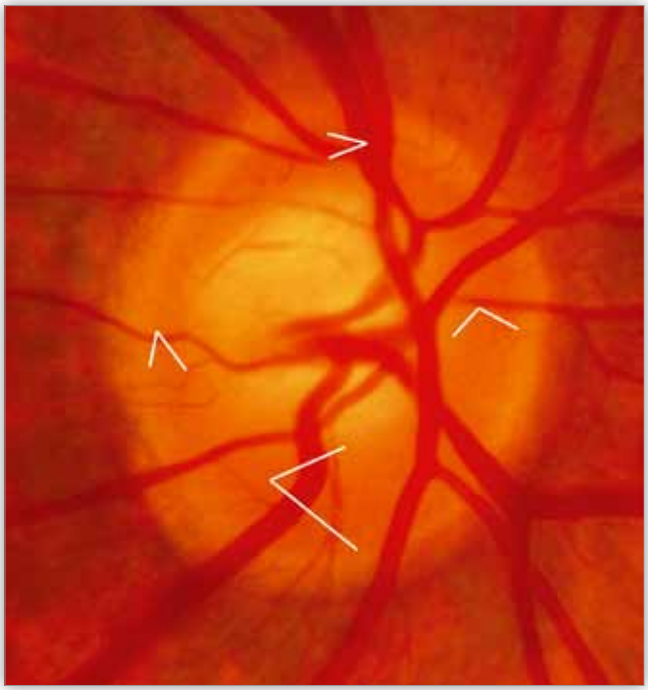

Fig. 14. The rim is thinner superiorly than in other sectors (a violation of the ISNT rule), but the vertically oval shape of the cup is subtle.
Ryc. 14. Rąbek jest cieńszy od góry (pogwałcenie zasady ISNT), ale pionowy kształt wnęki nie jest wyraźny.

in which early glaucoma might be difficult to recognize if axons were lost inferiorly. Of course, with very small loss of tissue it may not be recognized at first if there is reasonably abundant normal tissue. Figure 16 is such an example in which very early glaucoma can be recognized by thinning of the neuro-retinal rim superiorly, but only with very careful examination. The appar-

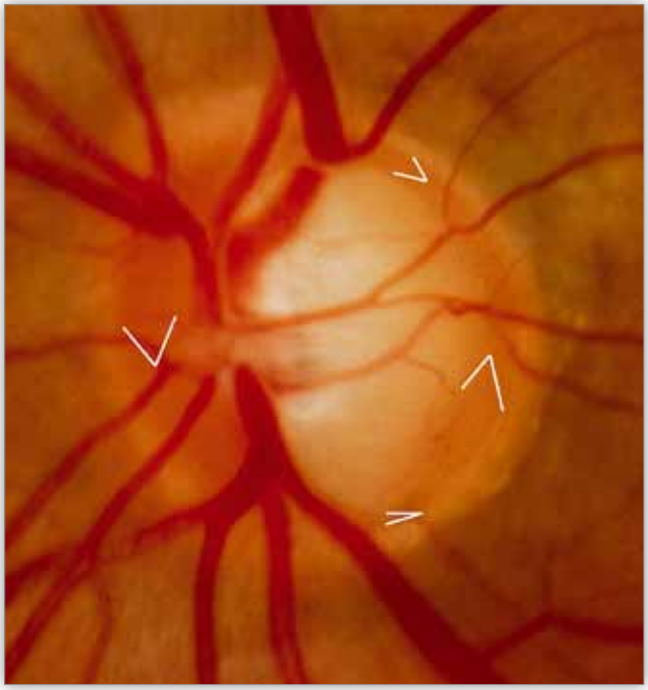

Fig. 15. Glaucomatous cup difficult to recognize from the shape of the cup. The rim is clearly thin in the superior and inferior locations, but the vertically oval shape of the cup is difficult to discern. Hence, as in the pervious figure as well, it is more important to pay attention to the rim width than to the shape of the cup.

Ryc. 15. Tarcza jaskrowa trudna do rozpoznania na podstawie kształtu wnęki. Rąbek jest wyraźnie węższy do góry i dołu, ale pionowy kształt wnęki nie jest oczywisty. Dlatego, tak jak na poprzedniej rycinie, ważniejsza jest ocena szerokości rąbka niż kształtu wnęki.

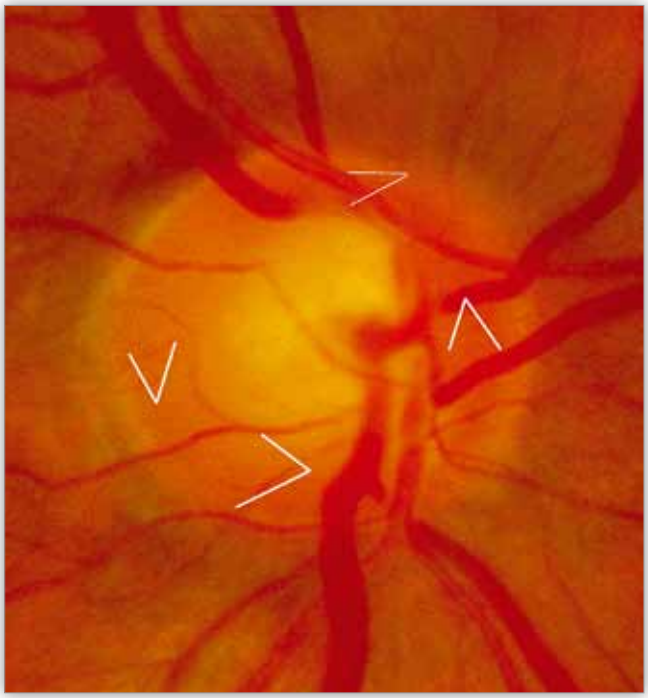

Fig. 16. Another example of a thin rim superiorly, but overall the neuro-retinal rim appears healthy and this sign of glaucoma is easily overlooked.

Ryc. 16. Inny przykład cienkiego rąbka od góry, ale ogólnie rąbek sprawia wrażenie zdrowego i objaw jaskry może być łatwo przeoczony.

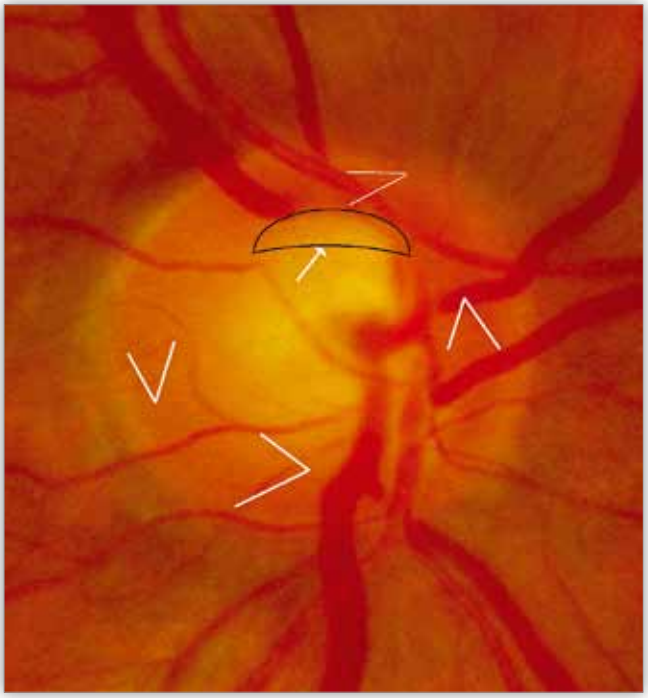

Fig. 17. Same disc as figure 16, showing the apparent region of neural loss (outlined in black), to account for the thin remaining rim superiorly. The presumed previous location of the cup margin superiorly is indicated by the black arc indicated with a white arrow.

Ryc. 17. Ta sama tarcza co na rycinie 16. wykazuje wyraźny obszar utraty tkanki nerwowej (obrysowany na czarno) będący powodem ścieńczenia rąbka od góry. Domniemana pierwotna pozycja brzegu wnęki od góry zaznaczona jest czarnym łukiem wskazanym białą strzałką.

ent region of collapsed tissue is outlined in black in figure 17. It can be recognized as glaucomatous by the fact that the rim of neuro-retinal tissue is much narrower at the superior pole than elsewhere around the circumference. It is easy to overlook this finding. Even after noting that the rim is thin in a particular location, it is hard to be completely convinced, because the rest of the disc appears so healthy. Like some other examples of early glaucoma illustrated here, this disc was initially considered to be healthy and a diagnosis of ocular hypertension was made. In this case and some others shown here as examples of early glaucomatous configuration, it was proved that glaucoma was indeed beginning, because over the next few years the disc showed further damage and became more obviously glaucomatous. However, not all cases are obvious, and diagnostic evaluation is not perfect (6).

Eyes that have large physiologic cups are not immune to developing glaucoma. Careful examination of the rim is important here. Figure 18 shows that with careful examination, nearly all of the neuro-retinal rim is absent, if one is careful enough to note the location of the disc boundary, and the examiner does not include the adjacent beta zone of peripapillary atrophy as part of the neuro-retinal rim, which is not always easy to do without a magnified view and a well focused beam of illumination. The ISNT rule that characterizes healthy discs is violated when the true neuro-retinal rim is considered and the beta zone excluded. By way of comparison, Figure 19 shows a large physiologic cup without glaucomatous damage. There is no lo-

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Fig. 18. Glaucoma in a large disc. Especially if the disc is somewhat tilted, it may be difficult to discern the presence of glaucoma, except by noticing the extremely thin rim of tissue superiorly after correctly identifying the disc edge so that the adjacent beta zone is not mistaken for neural tissue.

Ryc. 18. Jaskra w dużej tarczy. Szczególnie jeśli tarcza jest trochę pochylona, stwierdzenie obecności uszkodzenia jaskrowego może być utrudnione. Dopiero zauważenie krańcowo cienkiego rąbka od góry po prawidłowej identyfikacji brzegu tarczy, tak że przylegająca strefa beta nie jest utożsamiona z tkanką nerwową, pozwala na rozpoznanie uszkodzenia jaskrowego.

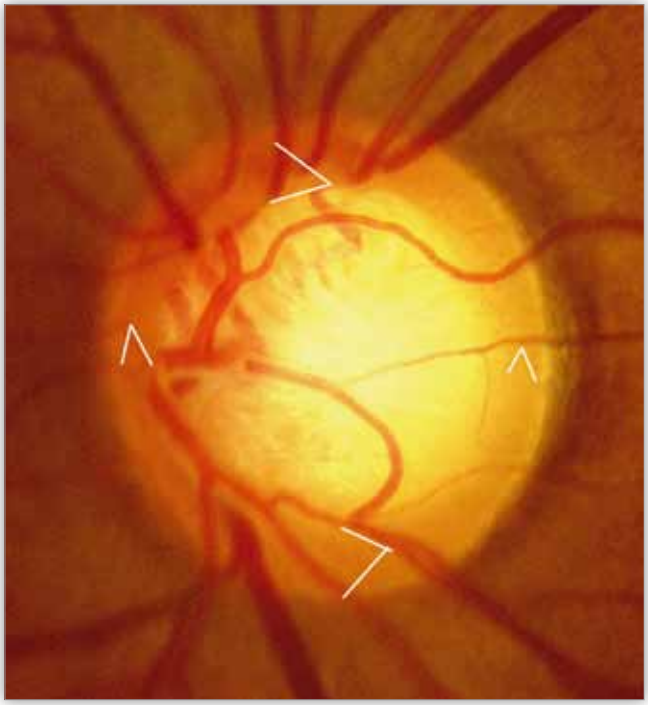

Fig. 19. Large disc with physiologic cup. In contrast to figure 18, the rim of neuro-retinal tissue is not thinner in the vertical meridians than elsewhere.

Ryc. 19. Duża tarcza z fizjologicznym zagłębieniem. W przeciwieństwie do obrazu z ryciny 18. rąbek nerwowo-siatkówkowy nie jest cieńszy w południkach pionowych niż gdzie indziej.

calized thinning of the neuro-retinal rim. Large discs with large excavations are among those difficult to evaluate accurately.

I would like to illustrate (Fig. 20) that the highly localize loss of axons and neuro-retinal rim tissue need not always be in the vertical meridian. Infrequently, the localized loss of tissue can be elsewhere around the circumference, and in this illustration the cupping extends nasally beyond the truck of vessels, and the rim of remaining neuro-retinal tissue is very thin. This would correspond to a temporal visual field defect, which is often not conspicuous in the 24 degree visual field test often used these days, as so few points are tested temporally.

I believe that with careful attention to the neuro-retinal rim, looking for localized loss of tissue, especially in the inferior and superior regions of the disc, it is often possible to recognize cases of glaucoma when they are first developing, with a different appearance from most normal discs (Fig. 21). This can be important for cases of normal-tension glaucoma in which the only sign of glaucoma on a routine examination is the optic disc, and only after that is a visual field test obtained in order to confirm the diagnosis. It is also important in patients with abnormally high intraocular pressure (ocular hypertension), so that in those cases that convert to glaucoma can be recognized as early as possible. In instances of ocular hypertension there may be the advantage of baseline photographs, and a change in the configuration of the rim and of the cup signifies the emergence of glaucoma.

Of course there will always be doubtful cases (6), and such cases are likely to be very mild or early cases, perhaps with no field defect yet detectable, or ones with large discs, tilted discs, or other variations in normal anatomy. Baseline photographs and observation of change over time are very useful in such doubtful cases. It should also be noted that other diseases cause loss of axons. Usually these other types of optic atrophy have a different appearance on clinical examination. In glaucoma, the lamina cribrosa typically collapses in the same region as the axon damage, so that excavation is highlighted in the affected portion of the disc. The healthy portion of the disc has no excavation in addition to a healthy appearance to a healthy color. In the other optic atrophies, the disc tends to turn pale in the regions without axons, but without obvious excavation. An exception occurs in patients who have a large physiologic cup that was cylindrical in shape rather than conical. In such cases, as axons disappear, the rim does indeed get narrower in the affected region. Sometimes remaining tissue in the thin region may be pale (whereas in glaucoma it tends to be excavated in damaged areas and remaining rim tissue is of healthy color), but often in discs with large physiologic cups beforehand, it is difficult to distinguish thinning of the rim from glaucoma from thinning of the rim from other causes. The most frequent examples are cases of arteritic anterior ischemic optic neuropathy (AION). Usually there is not such a diagnostic difficulty in non-arteritic AION, because the discs are small with small physiologic cups, and the main finding after the swelling has subsided is that the affected disc tissue is pale.

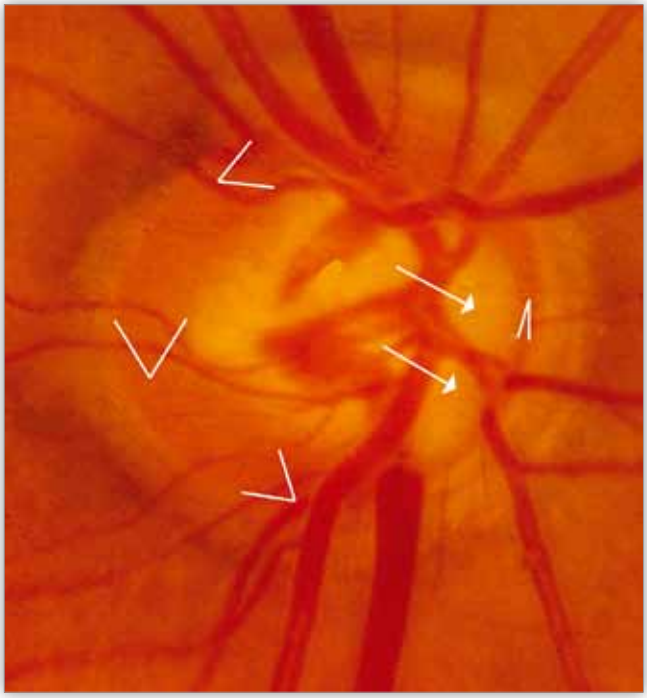

Fig. 20. Glaucomatous disc with main tissue loss nasally. Glaucoma is characterized by localized loss of axons. Although while usually in the vertical meridians of the disc where the arcuate nerve fiber bundles are received, it can be in other places. Cupping on the nasal side is easily overlooked because the visual field has few corresponding test locations to call attention to damage in this region of the disc.

Ryc. 20. Tarcza jaskrowa z głównym ubytkiem tkanki od nosa. Jaskra charakteryzuje się miejscową utratą aksonów. Chociaż zwykle dotyczy to południków pionowych tarczy, gdzie wchodzą łukowate pęczki włókien, to jednak może występować w innych miejscach.

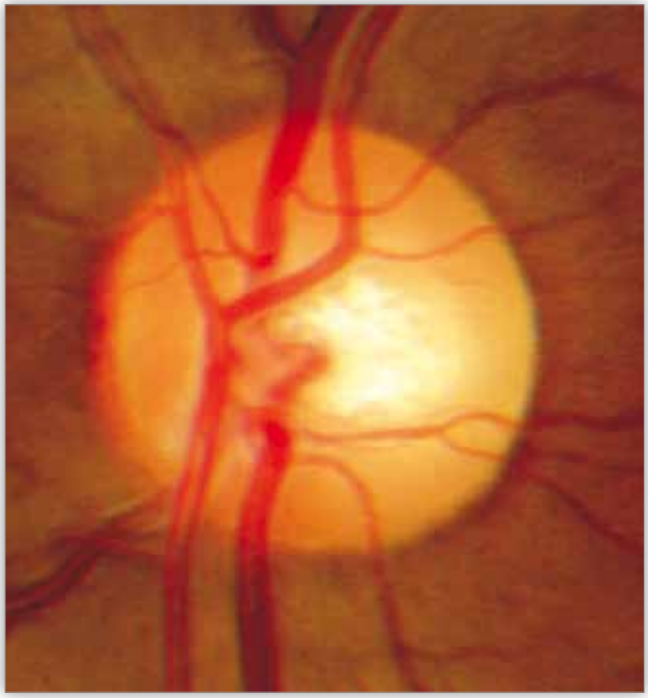

Fig. 21. Normal disc without glaucoma. After looking at a series of glaucomatous discs, a very healthy disc is strikingly different. While some discs may have borderline clinical features, a clearly normal disc like this one can permit the diagnosis of ocular hypertension to be made with confidence.

Ryc. 21. Prawidłowa tarcza bez jaskry. Po obejrzeniu wielu tarcz jaskrowych można stwierdzić, że całkowicie zdrowa tarcza jest uderzająco odmienna. Podczas gdy wiele tarcz może mieć graniczne cechy kliniczne, całkowicie prawidłowa tarcza, jak na tej rycinie, pozwala na wiarygodne rozpoznanie nadciśnienia śródocznego.

Recognition of glaucoma in advanced stages is usually not difficult for an experienced ophthalmologist. I hope that some of these illustrations will help in making careful observations to permit recognition of mild cases and those that are just beginning. I thank you again for the honor of speaking in memory of Dr. Tadeusz Krwawicz, and the additional honor of asking for my remarks be prepared for publication for you and your students to use for future reference.

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