PURTSCHER, (O)

1) A SUGGESTION CONCERNING THE CORRECTION BY GLASSES OF CERTAIN ANOMALIES OF THE CURVATURE OF THE CORNEA

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A SUGGESTION CONCERNING THE CORRECTION BY GLASSES OF CERTAIN ANOMALIES OF THE CURVATURE OF THE CORNEA.

By Dr. O. PURTSCHER, of Klagenfurt, Austria.

Translated, abridged, by Dr. A. Schapringer, of New York.

LAQUEUR[1] has recently published the valuable results of a series of ophthalmometric measurements carried out under normal as well as under pathological conditions. Among the latter were keratoconus, glaucoma, paralysis of ocular muscles, parenchymatous keratitis, coloboma of the iris and choroid, zonular cataract, iritis, etc., and also cases of extraction of cataract, iridectomy, strabotomy, and accidental injuries. He determined the different curvatures in the different meridians, or the co-called regular astigmatism, but did not pay any attention to differences of curvature in one and the same meridian. The latter subject has already been touched upon by Mauthner,[2] in the course of his elucidation of the subject of acquired regular *As*, especially of traumatic astigmatism (pp. 786, 787), and of that of irregular astigmatism (p. 801).

According to this author cylindrical glasses, as a rule, greatly enhance the acuteness of vision in eyes recently operated upon for cataract; later on they not only do not improve S, but lessen it, the patients seeing better with simple spherical glasses than with cylindrical combinations. This is explained by assuming that the cicatricial contraction

[1] Ueber die Hornhautkrümmung im normalen Zustande und unter pathologischen Verhältnissen. Ophthalmometrische Untersuchungen. *Von Graefe's Arch.*, Bd. xxx., I, pp. 99–134.

[2] Vorlesungen über die optischen Fehler des Auges. Wien, 1876.

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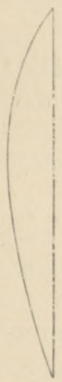
neutralizes the regular as well as the irregular astigmatism caused by the operation.

As to the variety and degree of *As* caused by the operation of extraction of cataract, Laqueur states that as a rule the vertical meridian is flattened. He found its curvature increased in a few cases only. The difference of curvature in the two principal meridians was at least 1.5–2 D during the first two weeks, usually it was 3–4, and occasionally 6–7 D. In one exceptional case of irregular cicatrization it was 16 D. In the course of the following weeks he found the traumatic *As* decreasing, and at the end of the third or fourth month the condition of the refraction became stationary, but the *As* never disappeared entirely.

My own practical observations concerning traumatic *As*, its variety and corrigibility by convex cylinders with horizontal axis, and also its subsequent decrease, coincide with those made by Laqueur in every respect. There is, however, one point to which too little attention has been paid up to this time, and to which I wish to draw the attention of my colleagues.

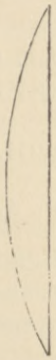
Although I have not made any ophthalmometric measurements myself, I think I am justified in assuming that in cases as those spoken of before, the radius of curvature differs in different parts of one and the same meridian. In cases of extraction of cataract for instance, if the incision be performed above, the lower or corneal border of the wound will protrude somewhat over the upper or scleral border, and consequently the uppermost portions of the vertical meridian will become flattened considerably, while the flattening will become less perceptible in the lower portions, which are further removed from the line of incision.

It is an indubitable fact that in many cases of irregular cicatrization after operative or accidental traumatism of the cornea, the glasses now in use do not accomplish all that is desired, and that there is considerable room for their improvement. This improvement could be effected if lenses were produced analogous to the cylindrical lenses such as are employed at the present time, but with the radius of curvature varying in different parts of one and the same meridian, so as to correspond to the peculiar optical defect of the cornea spoken of. On a longitudinal section a lens such as here proposed would present an elongated rectangle, the same as a common cylindrical glass. A transverse section, however, would differ from that of a cylindrical lens as shown in these diagrams:



Proposed modification.

FIG. 1.



Cylinder.

FIG. 2.

I do not know whether such a modification has already been proposed by somebody else or not. If it has been, the suggestion has been allowed to drop into oblivion.

Upon inquiries made of Mr. F. Fritsch, the well-known optician of Vienna, I was informed that the production of such lenses was feasible, but that the construction of the necessary plant would involve an inordinate outlay of money on account of the undeveloped character of the technical appliances at our command at the present time.

For this reason I have been debarred from making any practical experiments myself, but I don't doubt that further investigation of this subject by ophthalmic surgeons, combined with improvements made in the technical appliances, will lead to good results in the direction suggested by this article.

ON THE PROBABLE CAUSE OF THE COLORED RINGS SEEN IN GLAUCOMA.

By Prof. W. DOBROWOLSKY, of St. Petersburg, Russia.

Translated by Dr. A. Schapringer, of New York.

SINCE the investigations of Donders on this subject have been published,[1] the appearance of colored rings surrounding flames in glaucoma has been generally attributed to a cloudy condition of the transparent media of the eye. Mauthner[2] has been the only one to enunciate the opinion that the appearance of these rings may be a phenomenon of nervous irritation only. He based his opinion upon the analysis of a single case only, and did not enter into a discussion of the nature of this irritation.

Observations which I have made enable me to record certain conditions under which colored rings will make their appearance, while the refracting media remain entirely clear.

Young persons suffering from progressive myopia often complained to me about such colored rings. In several of these cases myopia was complicated with spasm of accommodation, but without any diminution of S. In all of them the background of the eye showed symptoms of irritation. The optic disc was red, its outlines ill defined, and the choroid showed the recent changes peculiar to progressive myopia. There were usually photophobia, lachrymation, photopsia, and spells of asthenopia. It is a noteworthy fact that atropia and blood-letting always made the colored rings dis-

[1] *Arch. f. Ophth.*, Bd., viii., 2, p. 166 *et seq.*

[2] "Die Lehre vom Glaucom," 1882, p. 48 and 49.

appear for a more or less considerable period of time, together with the other symptoms complained of. In Mauthner's case the patient saw rainbow-colored rings, at first with the right eye alone, in which an apparent myopia of $\frac{1}{50}$, found upon examination, disappeared again in the course of a few days. I wish to lay stress upon this apparent myopia, because in all the cases of spasm of accommodation observed by me, I always found hyperæmia in the fundus. I regret that in the case of Mauthner no note has been made of the ophthalmoscopic appearances, and that the refraction has not been determined under atropia.

I will here add some observations made upon my own eyes.

Several years ago I began to notice colored rings around a light while in a Russian bath. At first I thought that the appearance of these rings was caused by the hazy condition of the air due to the presence of steam. By closer analysis, however, I found that the cause was to be sought elsewhere. On entering the bath room, saturated though it was with steam, I did not see the rings immediately, but only after the lapse of about half an hour, during which time I washed my head with pretty hot water, which reddened the skin of my skull and face and the conjunctiva of the lids as well as that of the eye-balls, and caused a sensation of heaviness in my head. It was only then that I began to see rainbow-colored rings around the gaslight, which became even more distinct if I left the hot chamber for a cooler one in which there was considerably less steam. The rings showed all the colors of the spectrum, from red which formed the outer border, to blue which formed the inner border. I could not distinguish indigo and violet, which was evidently owing to the slight intensity of these colors. In consequence of the absence of the last-named two colors, there was a dark space between the innermost or blue ring and the flame.

The colored rings gradually faded away, keeping step with the subsidence of the hyperæmia of the head and face after leaving the Russian bath. After they had disappeared entirely, I could recall them by pressing upon the globe long enough to make all objects disappear from view for a few moments. On releasing the pressure, and after the objects had been in view again for a few seconds, the colored rings returned and were quite distinct.

For the last few months I have constantly seen these rings around the lamp-light in the evening. They are much more distinct with the right eye than with the left. There is no noticeable increase of tension, and the visual acuteness is $\frac{25}{20}$, above normal, the same as it always has been during the last twenty years. Tension of accommodation, either by fixing the rainbow circles or by using concave glasses, always renders them more distinct, the same as pressure upon the eyeball.

It follows from these observations and experiments that rainbow rings may be seen by eyes which are free from cloudiness of the refracting media. In the cases of progressive myopia, the absence of opacities discernible with the ophthalmoscope and the perfect visual acuteness tend to disprove the assumption of slight cloudiness of the vitreous, which could be made on the base of analogy. As to my own eyes, their supranormal acuteness of vision persisting during the appearance of the colored rings excludes every idea of haziness of the media. Neither can the results of my experiments by pressure exerted upon the globe and by tension of the accommodation be satisfactorily explained by any sudden change in the refracting media.

The only way to explain this phenomenon is to assume that it depends upon the irritation of the retina and the optic nerve by hyperæmia.

ON THE ORIGIN OF STRABISMUS.

By Professor J. STILLING, of Strasburg, Germany.

Translated (abridged) by Dr. A. Schapringer, of New York.

IT is generally assumed that in the position of rest the visual axes of both eyes are parallel. This is true, however, only in a limited number of cases. The fact is that with the majority of mankind the position of rest is a squinting position. In my own case it is convergent, as I have found out by relaxing my ocular muscles whilst gazing at a solitary bright star, which then appears in homonymous double images. I obtain the same results by relaxing the ocular muscles whilst looking at nearer objects. The well-known equilibrium test with vertical prisms confirmed this result.

Furthermore, after closing one eye gently while looking at a star or at a candle flame at the distance of six metres, I see homonymous double images at the instant of re-opening, the images standing farther apart than in the prism test. There are two ways of explaining this phenomenon : either the eyeball was forced mechanically into the convergent position by the effort of closing the lid, or it went into that position as being the one of natural equilibrium. A series of tests made with a number of medical men, in which crossed diplopia was the result obtained, prove the latter explanation to be the correct one. In their cases divergence was the position of rest. The reliability of the tests is made evident by the fact that Messrs. Goltz, Witkowski, and Ewald were among those who made these experiments for me.

The test just spoken of seems to prove that in quiet dreamless sleep the eyeballs as a rule occupy the position of equilibrium peculiar to the individual, which may be either convergence, divergence, or parallelism, whereas the observations of Raehlmann and Witkowski have shown that during sleep the coördination of both eyes is suspended, there being neither associated nor convergent movements as in binocular vision.

I have examined many persons according to the above methods, and have found that in the position of rest most eyes are convergent, many divergent, a few only are parallel.

Since eyes squint when at rest, the question naturally arises whether strabismus is not the maintenance of the position of rest (or of a position approaching it), with renunciation of binocular vision ?

According to the well-known theory of Donders, the convergent squint of hypermetropic eyes is based upon the law, discovered by him, of the relative range of accommodation, which formulates the interdependence of accommodation and convergence. But this law is valid only as long as relative accommodation is possible, *i. e.*, as long as there is binocular fixation, which is a *conditio sine qua non* of relative accommodation. Binocular fixation being abolished in strabismus, the law of relative accommodation which applies only to binocular vision forthwith loses its force.

I have made comparative tests on the basis of the experiments mentioned before in numerous series of cases, comprising all the different states of refraction, including astigmatism and anisometropia. The results have been as follows :

In each form of refraction every variety of the position of rest may occur. In a great majority of cases of hypermetropia the position of rest is convergence, whilst in myopia it is divergence. In emmetropia the rule is convergence. I will quote some figures to prove this. Among the 57 pupils of the Teachers' Seminary of this city I found 10 myopes. Of the latter number convergence proved to be the position of rest in two cases only, in all the rest it was divergence. Of the number of 16 hyperopes among them, not a single one showed divergence as the position of rest, it being found to be convergence in all of them. Of the 27 emmetropes two showed divergence, two parallelism, all the others convergence. Of the three pupils having myopic astigmatism, two showed convergence and one divergence. Among 40 medical students I found 16 myopes, in 9 of whom divergence proved to be the position of rest. Among 22 myopes examined in the dispensary it was divergence in 14 cases. These figures will suffice without my going into further particulars. During the last few months I have examined 65 myopes and 86 emmetropes in Strasburg alone. Among the former divergence was the position of rest in 41 cases; among the latter it was convergence in 68 cases.

These facts prove not only that in the majority of people the position of rest for the eyes is convergence, but also the variety of the form of rest of non-squinting hypermetropic and myopic eyes corresponds to the variety of squint predominant in these two classes of abnormal refraction. The predominance of convergence in hypermetropia is greater than that of divergence in myopia. The position of rest has therefore to be considered as an important factor in the production of squint.

I next considered the relations of the position of rest to adduction and abduction.

I made the necessary tests according to the principles laid down by Von Graefe, but soon found that it was sufficient for the purposes of this investigation to compare distal abduction with distal adduction. This is done by placing a lighted candle at a distance of six metres in front of and on a level with the eyes of the person examined, and making him look through prisms with the basis inward and then outward. The values received in this manner for distal abduction do not differ materially from those obtained by first approximating the candle whilst lowering the visual plane, and only gradually removing it.

Distal abduction in normal eyes amounts to 4° to 6°, as can be easily verified; distal adduction fluctuates between 14° and 24°. Adduction of more than 20° is rare, the rule being 14 to 16°. Abduction of more than 6° and adduction of less than 12° are to be considered as abnormal.

The relations of the values of abduction and adduction to the position of rest of ametropic eyes are by no means constant. Thus, for instance, there may be increased abduction with very good adduction, the position of rest being divergence.

Example :

J. S. Myopia 1 D and 3 D.

Position of rest : divergence. No dynamic divergence anywhere with the ordinary tests.

Abd. = 12°.

Add. = 22°.

One may be inclined to explain the position of rest in this case by an elastic preponderance of the external recti muscles, while adduction at the same time is very good. But there are cases in which abduction is not excessive, and adduction abnormally great, whilst the position of rest is, nevertheless, divergence.

B. W. Hypermetropia.

Abd. = 6°.

Add. = 25°.

Position of rest : divergence.

If the position of rest depended upon muscular preponderance only, that position in this case would have been convergence instead of divergence. In a certain number of hypermetropes convergence is the position of rest, although abduction is increased and adduction abnormally weak.

M. L. Hypermetropia 4 to 5 D.

Distal abduction = 10°.

Proximal abduction (von Graefe) = 20°.

Position of rest : convergence.

It can be easily proved that in certain cases, be it of hypermetropia or myopia, there may be insufficiency of the interni muscles, or even relative actual divergent squint, whilst the position of rest is nevertheless convergence. This position is, as a general rule, therefore, not dependent upon the muscular conditions, though such may be the case in some individual instances. In the following case it was evidently influenced by absolute weakness of the interni muscles:

K., M.D. Hyperopia 8 D.
Abd. = 10°.
Add. = 2°; proximal add. = 8°.
Position of rest: divergence.

There was relative actual divergent squint without a correcting glass—with the latter there was fixation for a short while only.

In a considerable series of cases the muscular conditions were exactly the same, and the position of rest were nevertheless different.

(1.) W., student of med.	(2.) Dr. O.
Hyp. = 2 D.	Myopia = 3 D.
Abd. = 6°.	Abd. = 6°.
Add. = 8°.	Add. = 8°.
Relative actual diverg. squint.	Relative actual diverg. squint.
Position of rest: convergence.	Position of rest: divergence.

From these two cases the inference could be drawn that the position of rest does not depend upon the condition of the ocular muscles, but upon that of the refraction. But the following two examples show that the refraction as well as the muscular conditions may be identical, and still the position of rest may be different:

(1.) F. L.	(2.) M. M.
Hyperopia = 2 D.	Hyperopia = 2–3 D.
Abd. = 6°.	Abd. = 6°.
Add. = 12°.	Add. = 12°.
Position of rest: convergence.	Position of rest: divergence.

In high degrees of myopia the position of rest has been found to be indiscriminately either convergence, even in cases of insufficiency of the interni, and in relative divergent squint, or divergence, the latter position having been found combined with abnormally increased adduction. An instance of the last-named combination is the case of Dr. Hoffmann, who has made a special study of the relations between the muscular conditions and the state of refraction, and who has a myopia of 9 D and the abnormally great adduction of 90°, in whom divergence is the position of rest. In high degrees of hyperopia it is either divergence or convergence.

Among the factors to be taken into consideration as influential in determining the position of rest (besides refraction and the muscular condition), and which have not been made the object of study as yet, are the shape of the orbital cavity, the topographical relations of the fibrous structures and other soft parts surrounding the globe, the position of the entrance of the optic nerve, and perhaps also the angle α. In emmetropia as well as in hyperopia these factors probably favor convergence as a position of rest, whilst in myopia the opposite is likely to prove to be the case.

Schweigger explains convergence and divergence as positions of rest in the same way as actual squint, namely by the elastic preponderance of certain ocular muscles, but as has been shown above, there are other factors besides this preponderance which have to be taken into consideration.

It is easily seen from the example detailed above, that insufficiency of the internal recti is apt to be diagnosticated in cases where there is none. This is often done in myopia, as has been admirably shown by Schweigger.[1] The true explanation of the apparent insufficiency is, that the eye, when excluded from binocular fixation by the covering hand, passes into its position of rest. Tests performed with the aid of prisms will furnish proof in such cases that the deviation of the eyeball is not due to a pathological condition of the muscular apparatus, but that it is a physiological phenomenon.

With the aid of these newly discovered facts it will not be difficult to differentiate between apparent or physiological squint and real pathological strabismus.

Normal vision is a continued struggle of the ocular muscles for binocular fixation against natural obstacles. If for one reason or another one eye becomes unable to keep up

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[1] Klinische Untersuchungen über das Schielen, pp. 64 and 65.

this struggle, or if it becomes impossible for both eyes to continue it in unison, then either one eyeball or both alternately will pass into the natural position of rest. Abolition of binocular vision may be due to many causes, and may originate either in the muscles or in the eyeball itself, or in both. In the majority of cases they originate in the eyeball and are well known to us. I allude to differences of refraction and to the different varieties of amblyopia. To these we must add all general and local causes tending to weaken accommodation or to suspend it altogether.

In hypermetropia the position of rest is convergence. Now, if by reason of congenital amblyopia, an excessive difference of refraction or of some other cause, one eye is incapable of participating in binocular fixation, the laws of relative accommodation will become inoperative and the eyeball, instead of assuming a convergent position corresponding to the object fixed, will pass into its individual position of rest. If this position is a marked convergence, convergent strabismus will ensue. If it be slight convergence only, the consequence will be relative divergent strabismus, either permanently or only temporarily, changing later on into absolute convergent squint, by reason of secondary atrophy of the relaxed external rectus and contracture of the internal muscle.

In such cases the matter is clear and simple. But how is it in cases where both eyes are evenly and only moderately hypermetropic, and where both are possessed of normal visual acuteness? It is well known that in monocular vision we can dispose of the whole range of accommodation, whilst in binocular vision we are subject to the laws of relative accommodation. In hypermetropes the positive part of the relative range of accommodation is apt to become too small as compared with the negative part, rendering it impracticable to keep up the effort of accommodation pertaining to a certain position of convergence for any length of time, or even to attempt it at all. But as we have seen above, the faculty of convergence, whether sustained by the external or the internal rectus muscle, is difficult to maintain whenever the power of accommodation makes default, and therefore one of the eyes, or both alternately, pass into the position of repose. By sacrificing binocular vision, the hypermetrope emancipates himself from the laws of relative accommodation, the positive part of which has become too small, his absolute accommodation becomes free for monocular vision, and asthenopia disappears partly or entirely.

The position of rest for hypermetropes being strong convergence, active contraction of the external recti muscles will be necessary, even for shorter distances, in order to sustain binocular fixation. Under such circumstances squint may be produced by mere fatigue of the external muscles. This is more apt to occur when these muscles happen to be weak than when they are strong. In hypermetropes with strong convergence as position of rest, the external recti will naturally become strong by practice, and the increased power of abduction, combined with undiminished power of adduction, as met with by Ulrich[1] in many cases of this error of refraction, is hereby explained, and not by the assumption of relative insufficiency of the external recti muscles.

The cause of squint is not hypermetropia but the position of rest usually associated with hypermetropia, viz., convergence. On the main the results of my investigations coincide with the view enunciated by Schweigger.

According to what has been demonstrated above, divergent strabismus may occur where the position of rest is divergence, even without any insufficiency of the interni. Should they happen to be insufficient, this will of course form a favorable factor, and if they be absolutely weak, this circumstance alone would suffice to explain the development of divergent strabismus in myopia, the explanation being analogous to that of convergent squint, developing in cases of hyperopia and absolute weakness of the external recti muscles. It is in such cases the consequence of muscular fatigue only, and has nothing to do with the error of refraction either directly or indirectly.

There are rare instances of myopia combined with insufficiency of the external recti *and a convergent position of rest,*

[1] Die Aetiologie des Strabismus convergens hypermetropicus, p. 22.

and if squint develops in those cases, it will be of the convergent variety. *The prevalence of the divergent form of strabismus in myopia is not due to the anomaly of refraction as such, but to the prevalence of divergence as a position of rest in myopic eyes.*

That form of squint called parallel strabismus, to which Schweigger has called attention anew, easily fits into our theory. It concerns such rare cases in which the position of rest is parallelism or approaching it.

Ulrich, a recent author on our subject, has set out in search of "obstacles to the development of strabismus." The progress of our investigations has made these obstacles clear.

Let us first ask the question, Why do not all hypermetropes develop convergent squint?

The answer is the following:

1. In a number of cases of hyperopia the position of rest is divergence. If in such instances the internal recti become more or less insufficient, the consequent strabismus will be divergent.

2. With some hypermetropes the position of rest is slight convergence only. If strabismus develop in any of these, it could be only of the relative divergent variety, even if the interni should not be insufficient.

3. The position of rest may be divergence, without any insufficiency of the interni.

4. In a few isolated cases the position of rest is parallelism.

5. Some individuals are not capable of relaxing the external muscle of one side only, though their position of rest may be strong convergence and in spite of the presence of asthenopia.

6. And lastly, the majority of hypermetropes do not squint on account of the strong inherent desire for binocular fixation, and because the power of accommodation in youthful individuals is ample to overcome the disadvantages of hyperopia, as has been well elucidated by Schweigger.[1] They remain victorious in the struggle between bi-

[1] *L. c.*, p. 22.

nocular fixation and the position of rest, just the same as emmetropes, though it costs the former more of an effort. In other words, the majority of hypermetropes have no inducement to squint, just as little as emmetropes have. As regards higher degrees of hyperopia, the statistics of Schweigger[1] show that they are rare in the same proportion as cases of strabismus with the corresponding degree of hyperopia. On the whole, the same considerations hold good here as with hyperopic convergent strabismus in general. And finally, as Donders properly remarks, highly hypermetropic persons do not gain any thing by squinting. They could emancipate themselves from the laws of relative accommodation, but the power of accommodation of the fixing eye would still be insufficient.

Ulrich counts also the antagonism of the visual fields (Wettstreit der Sehfelder) among the abstacles to squint, which I mention here for the sake of completeness. The significance of insufficiency of the internal recti muscles, upon which this author lays so much stress, has, I believe, been correctly appreciated above.

A question, analogous to the one about the immunity of the majority of hypermetropes from convergent squint, can be raised about myopes. Why do they not all squint outward? The answer is the following:

1. Some myopes squint inward because their position of rest is convergence, and there may be insufficiency of the external recti besides.

2. The position of rest of many myopes is convergence. If this be only slight, only relative divergent squint can possibly develop. The same holds good for parallelism as position of rest.

3. Even if all circumstances are favorable for outward squint, it will not develop if the individual cannot learn to relax one internal rectus muscle in order to give the eyeball a chance to assume its position of rest.

4. Finally, the majority of myopes do not squint because they have acquired the faculty of shifting the range of relative accommodation in the interest of binocular fixation, so

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[1] *L. c.*, p. 21.

that the synergistic efforts of accommodation are reduced to a minimum.

The main obstacle to squint for ametropic eyes therefore is the same as for emmetropes, namely, preponderance of binocular fixation.

The subject of obstacles to squint comes up also in paralytic strabismus. Especially in paralysis of the abducens nerve the question may with propriety be raised: Why does not convergent paralytic squint develop in every case of paralysis of that nerve?

The answer now is simple: the development of inward squint depends in each case upon the position of rest. If it is divergence or parallelism, inward strabismus cannot develop. If the position of rest is convergence, the degree of squint and the rapidity of its development will depend upon the amount of this convergence and upon the strength of the internal recti muscles. Should the cause of the paralysis be removed, the disappearance of the consequent paralytic squint will depend upon the issue of the struggle between binocular fixation and the position of rest.

The spontaneous cure of squint also depends upon the same issue, as has been pointed out anew by Schweigger. Since such spontaneous cures occur as a rule during the period of growth, they are obviously the result of a change in the position of rest brought about by changes in the size of the globe and its adnexa.

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