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Analysis of the Qualitative Dermatoglyphics of the Digito-Palmar Complex in Patients with Primary Open Angle Glaucoma

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A B S T R A C T

The primary open-angle glaucomas are a group of diseases that have in common characteristic morphological changes at the optic nerve head and retinal nerve fiber layer, progressive retinal ganglion cells death and characteristic visual field loss. The risk for primary open angle glaucoma rises continuously with the level of the intraocular pressure. The disease advances slowly and there are no symptoms. Primary open angle glaucoma is caused by abnormal aqueous humour outflow in the trabecular meshwork in the open angle. Etiopathogenesis of primary open angle glaucoma is unclear. The increased risk of glaucoma in relatives has long been recognized. Frequency for manifestation of the disease is 10–30% in family members. The discovery of the specific gene loci responsible for the manifestation of glaucoma has helped us to understand its mechanism of origin and definitely confirmed the hereditary nature of this disease. Digito-palmar dermatoglyphs were already used to determine hereditary base of many diseases and it was the reason for investigation of their qualitative patterns in patients with glaucoma (22 males and 23 females), their immediate relatives (19 males and 23 females) in comparison to a group of phenotypically healthy population (52 males and 56 females). The results pointed a connection with the dermatoglyphic traits of the digito-palmar complex between patients with glaucoma and their immediate relatives. There is a possible discrimination of patients and their immediate relatives from phenotypically healthy population, too.

Key words: *dermatoglyphs, qualitative traits, primary open angle glaucoma, family history*

Introduction

Glaucoma is the second leading cause of blindness in the world after cataract, affecting approximately 70 million people, about half of whom are estimated to have open angle glaucoma[1]. The number of people suffering from bilateral blindness as a result of primary glaucoma has been estimated to be 6.7 million[2].

Primary open angle glaucoma (POAG) is a slowly progressive disorder that results in the loss of retinal ganglion cells and is clinically manifested by the gradual loss of the midperipheral visual field and excavation of the optic disk. The disease is insidious and patients frequently have no symptoms. In this glaucoma, trabecular meshwork appears to be completely normal on clinical examination.

The cause of POAG is yet unknown. Findings from epidemiological studies indicate that apart from high intraocular pressure (IOP)[3,4] and age[5], ethnic origin[3], diabetes mellitus[5] and family history[6] are associated risk factors. Evidence for genetic factors has been found for juvenile glaucoma[7], for selected families with adult glaucoma[8] and for normotensive glaucoma[9].

A genetic contribution to the pathophysiology of POAG has long been suspected, because some families have many affected memebers[10]. There are many studies about »screening« methods into families for this disease[11,12]. The discovery of the specific genetic loci responsible for the manifestation of glaucoma has helped us to understand its mechanism of origin and definitely confirmed the hereditary nature of this disease[13].

The formation of little channels in the trabecular meshwork is completed by the 21st week of the intrauterine life. These little channels are responsible for

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aqueous humour outflow, and thus for elevated IOP in patients with POAG. Since the trabecular meshwork develops simultaneously with dermatoglyphic traits of the digito-palmar complex**,** and from the same primary germ layers it may be expected that genetic changes, which influence predisposition for the manifestation of open angle glaucoma, may have an impact on the formation of dermatoglyphs in the early intrauterine life. It has been proved that a great number of dermatoglyphic traits have a hereditary base. Their analysis may be used for the examination of diseases etiology, for which there is a doubt that have a genetic predisposition. Open angle glaucoma belongs to the group of diseases with genetic predisposition, so that dermatoglyphic analysis will be used in this study.

Various epidemiological studies have showed that among immediate relatives of a patient affected by POAG, the frequency of disease manifestation is between 10–30%, so that immediate relatives of those affected with POAG may have special dermatoglyphic traits of the digito-palmar complex.

Therefore, our intention was to determine the following in this study:

1. whether differences in qualitative dermatoglyphic traits of the digito-palmar complex exist between patients with POAG and phenotypically healthy population
2. whether their family members, who are not affected by the disease, have the same dermatoglyphic traits.

Subjects and Methods

For the purpose of this study, 45 patients with POAG were examined. Those were patients in whose families two or more members affected by POAG were registered (22 males and 23 females). Another group is formed from the immediate relatives (19 males and 23 females) of such a family, who was not affected by POAG. Another control group consisted of 108 phenotypically healthy persons (52 males and 56 females), in whose families there have been no members affected by POAG. The clinical examination of all subjects included collection of a detailed family history of glaucoma, refraction, and application tonometry, as well as biomicroscopy with gonioscopy, ophthalmoscopy, and visual field testing by using standard full-threshold automated static perimetry.

In this study, the frequency of dermatoglyphic patterns on fingers, such as arches, ulnar loops, radial loops and whorls has been analyzed. Frequencies of patterns on palms, namely on the thenar and in I interdigital area, hypothenar, in II, III and IV interdigital area, as well as the position of axial triradius »t« on both palms have also been analyzed.

Qualitative data have been shown in relative frequencies. For the purpose of analyzing differences in qualitative data between examined groups, χ^2 test (Chi square test) for independent samples has been used. By estimating biological distances Hiernaux Δ g^{22}, similarities and differences between patients and control groups have been determined.

Results

Relatives frequencies of patterns on fingers are shown in Table 1, with all male and female groups examined (patients with POAG, their immediate relatives and phenotypically healthy population). Frequency of patterns on fingers of both hands has showed (Table 2) statistically significant difference between the group of patients with POAG and their immediate relatives (χ^2=11.287, p<0.01), as well as between the group of immediate relatives and phenotypically healthy population (χ^2=8.047, p<0.05). Relative frequencies of patterns on fingers of both hands in all groups of females examined have showed statistically significant differences when compared with healthy controls. So, for example, the frequency of patterns on fingers between the group of female patients affected by glaucoma and phenotypically healthy population is on the relevance level of (χ^2=16.254, p<0.01). The frequency patterns on fingers between the group of female patients with POAG and members of their immediate family have not showed statistically significant difference, while the frequency of patterns on fingers between the group of female patients affected by glaucoma and phenotypically healthy population has been statistically significant (χ^2=33.331, p<0.001).

Relative frequencies of patterns on the palm, particularly on the thenar and I interdigital area, then on II, III,

TABLE 1
RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERNS ON FINGERS IN PATIENTS WITH POAG, THEIR IMMEDIATE RELATIVES, AND CONTROLS

	N	Arch (%)	Ulnar loop (%)	Radial loop (%)	Whirl (%)
Male patients with POAG	22	5.5	55.9	7.7	30.0
Male immediate relatives	19	1.6	49.5	4.7	44.2
Male controls	52	2.7	58.7	5.8	32.9
Female patients with POAG	23	4.4	68.3	4.8	22.6
Female immediate relatives	23	6.1	77.0	3.5	13.5
Female controls	56	10.9	55.9	3.3	30.0

POAG – primary open angle glaucoma

TABLE 2
χ^2 TEST OF RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERNS ON FINGERS IN PATIENTS WITH POAG, THEIR IMMEDIATE RELATIVES, AND CONTROLS

	χ^2 test	p
Males		
Male patients with POAG / Male controls	ns	
Male patients with POAG / Male immediate relatives	$\chi^2=11.287$	$p<0.01$
Male immediate relatives / Male controls	$\chi^2=8.047$	$p<0.05$
Females		
Female patients with POAG / Female controls (N=23)	$\chi^2=16.254$	$p<0.01$
Female patients with POAG / Female immediate relatives	ns	
Female immediate relatives / Female controls (N=23)	$\chi^2=33.331$	$p<0.01$

POAG – primary open angle glaucoma

IV interdigital area and on the hypothenar of male and female patients with POAG and in both control groups (groups of immediate relatives and phenotypically healthy male and female population) have been shown in Table 3 and Table 4. By applying χ^2 test, statistically significant difference has been obtained only for relative frequencies of patterns in the hypothenar, among group of patients with glaucoma and phenotypically healthy male population ($\chi^2=5.728$, $p<0.01$). For other frequencies of patterns on the thenar and in interdigital areas between examined male groups, statistically significant difference has not been determined. Frequencies of patterns on the thenar, interdigital areas and the hypothenar between certain female groups have not shown statistically significant differences, too.

Relative frequencies of axial triradius on the palm in all examined male and female groups have been represented in Table 5 and Table 6. Statistically significant difference has been determined between the male group of patients with glaucoma and phenotypically healthy population, (Table 7) by comparing frequencies of axial triradius ($\chi^2=13.957$, $p<0.01$). There has been no statistically significant difference between the group of patients with POAG and members of their families. There has been statistically significant difference ($\chi^2=8.585$, $p<0.05$) between members of families of those affected by POAG and phenotypically healthy population. By comparing those suffering from glaucoma and phenotypically healthy female population, and by comparing those affected by POAG and members of their immediate families, and

TABLE 3
RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERNS ON PALMAR AREAS: THENAR AND I INTERDIGITAL AREA, II, III, IV INTERDIGITAL AREA AND HYPOTHENAR IN MALES

	Thenar/I (%)	II (%)	III (%)	IV (%)	Hypothenar (%)
Male patients with POAG (N=22)					
Right	13.6	4.5	4.5	13.6	45.5
Left	18.2	–	9.1	45.5	50.0
Total	15.9	2.3	6.8	29.6	47.7
Male immediate relatives (N=19)					
Right	10.5	–	10.5	15.8	42.1
Left	15.8	–	–	63.2	26.3
Total	13.2	–	5.3	39.5	31.6
Male controls (N=52)					
Right	7.7	7.7	9.6	13.5	25.0
Left	17.3	7.7	17.3	34.6	26.9
Total	12.5	7.7	13.5	24.0	26.0

POAG – primary open angle glaucoma

TABLE 4
RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERNS ON PALMAR AREAS: THENAR AND I INTERDIGITAL AREA, II, III, IV INTERDIGITAL AREA AND HYPOTHENAR IN FEMALES

	Thenar/I (%)	II (%)	III (%)	IV (%)	Hypothenar (%)
Female patients with POAG (N=23)					
Right	4.3	4.3	13.0	8.7	34.8
Left	8.7	4.3	8.7	21.7	17.4
Total	6.5	4.3	10.9	15.2	26.1
Female immediate relatives (N=23)					
Right	4.3	–	4.3	17.4	34.8
Left	–	–	13.0	34.8	34.8
Total	2.2	–	8.7	26.8	34.8
Female controls (N=56)					
Right	7.1	8.9	8.9	17.9	33.9
Left	7.1	1.8	10.7	30.4	32.1
Total	8.7	5.4	9.8	24.1	33.0

POAG – primary open angle glaucoma

TABLE 5
RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERN AXIAL TRIRADIUS ON PALMS IN MALES

	t (%)	t' (%)	t" (%)	Other (%)
Male patients with POAG (N=22)				
Right	54.5	13.6	4.5	27.3
Left	68.2	4.5	9.1	18.2
Total	61.4	9.1	6.8	22.7
Male immediate relatives (N=19)				
Right	57.9	10.5	10.5	21.1
Left	68.4	15.8	10.5	5.3
Total	63.2	13.2	10.5	13.6
Male controls (N=52)				
Right	82.7	11.5	3.8	1.9
Left	75.0	17.3	–	7.7
Total	78.5	14.4	1.9	4.8

POAG – primary open angle glaucoma

TABLE 6
RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERN AXIAL TRIRADIUS ON PALMS IN FEMALES

	t	t'	t"	other
Female patients with POAG (N=23)				
Right	65.2	13.0	4.3	17.4
Left	69.6	17.4	8.7	4.3
Total	67.4	15.2	6.5	10.7
Female immediate relatives (N=23)				
Right	69.6	17.4	4.3	8.7
Left	56.5	26.1	–	17.4
Total	63.0	21.7	2.2	13.0
Female controls (N=56)				
Right	58.9	25.0	7.1	8.7
Left	55.4	28.6	8.9	7.1
Total	57.1	26.8	8.0	8.0

POAG – primary open angle glaucoma

members of the families and phenotypically healthy population, statistically significant difference has not been proved.

The estimation of biological distance according to Hiernaux[22] Δ g (Table 8), which is calculated on the basis of frequencies of patterns on fingers and the palms, and from the position of axial triradius, has showed similarity between the group of patients with POAG and their immediate male relatives (Figure 1) and female relatives (Figure 2), who have been separated in a special cluster in comparison to healthy male and female population. Male and female patients with POAG are biologically closer to the groups of immediate relatives than to the phenotypically healthy population.

Discussion

Etiopathogenesis of glaucoma has still been unclear, although findings on the hereditary base of this disease have greatly facilitated its understanding. Mutations on MYOC gene on GLC1A loci chromosome 1q21–q31 are responsible for the manifestation of juvenile and primary

TABLE 7
χ^2 TEST OF RELATIVE FREQUENCIES OF DERMATOGLYPHIC PATTERN AXIAL TRIRADIUS ON PALMS IN FEMALES

	χ^2 test	p
Males		
Male patients with POAG / Male controls	$\chi^2=13.957$	$p<0.01$
Male patients with POAG / Male immediate relatives	ns	
Male immediate relatives / Male controls	$\chi^2=8.585$	$p<0.05$
Females		
Female patients with POAG / Female controls (N=23)	ns	
Female patients with POAG / Female immediate relatives	ns	
Female immediate relatives / Female controls (N=23)	ns	

POAG – primary open angle glaucoma

TABLE 8
HIERNAUX Δg BIOLOGICAL DISTANCES

	POAG Males	Male immediate relatives	Male controls
Male patients with POAG	–		
Male immediate relatives	4840.96	–	
Male controls	5888.09	5468.08	–
	POAG Females	Female immediate relatives	Female controls
Female patients with POAG	–		
Female immediate relatives	5019.28	–	
Female controls	5105.87	5711.68	–

POAG – primary open angle glaucoma

open angle glaucoma in adults. New chromosome loci for POAG, congenital glaucoma and some syndromes related to glaucoma have recently been discovered.

Findings related to specific gene loci responsible for the manifestation of glaucoma have confirmed the family manifestation of this disease. In some families, there have been a greater number of those affected by POAG. Various epidemiological studies have confirmed family manifestation of the disease and positive family history as a relevant risk factor for the manifestation of the disease, which has confirmed a great impact of genetic factors in the ethiopatogenesis of the disease.

In this study, examinations of dermatoglyphic traits of the digito-palmar complex have been based on the fact that their formation is completed by the 21st week of gestation and they stay unchanged during lifetime, as well as on the fact that the formation of little channels in the trabecular meshwork of the ocular angle is completed by the 21st week of the intrauterine life. Dermatoglyphs of the digito-palmar complex and the structures of the chamber angle, responsible for the right aqueous humour outflow, are formed from the same hereditary base (dermatoglyphs from ectoderm and mesoderm, and structures of the chamber angle from mesoderm).

Environmental and genetic factors which could have influence, during the intrauterine development, the formation of dermatoglyphs may have an impact on the hereditary base of other organs, such as on the chamber angle and genetic predisposition for the manifestation of certain diseases later in life. That is the case for example with primary open angle glaucoma, which increases after the age of 40. In spite of numerous efforts to clarify the etiopatogenesis of this disease, it has still remained unclear. Risk factors mostly go in favour of the development of the disease. The examination of dermatoglyphic traits of the digito-palmar complex has been performed in various diseases and pathologies of unclear etiology, for which there has been a doubt that have genetic predisposition, in order to clarify the predisposition for their manifestation[23].

There are a number of diseases which show more or less differences in dermatoglyphic traits in comparison to healthy population. In various types of leukaemia, changes in qualitative dermatoglyphic traits have been discovered. In acute lymphocyte leukaemia, lower frequency of whorls has been noticed on fingers. In acute myeloid leukaemia, greater frequency of radial loops on fingers and patterns on the hypothenar has been notices, as well as

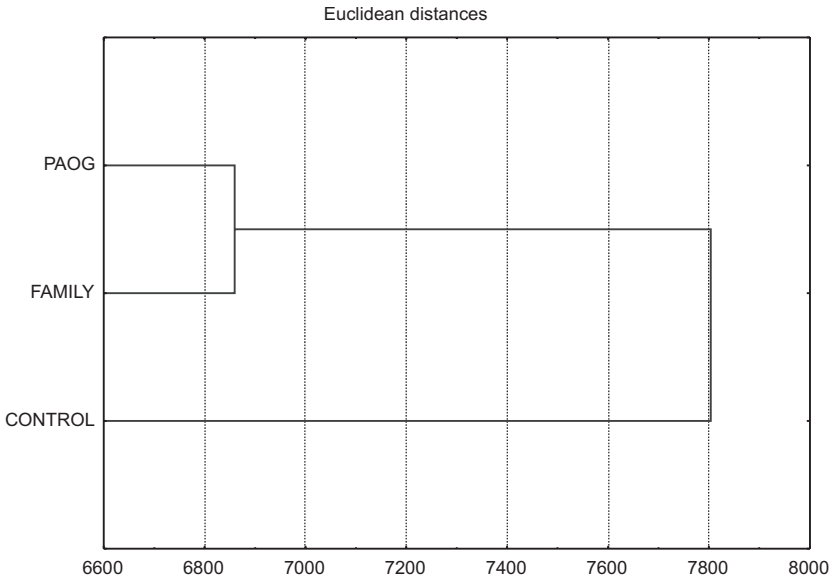

Fig. 1. Hiernaux Δg biological distances between male patients with PAOG, their immediate relatives, and controls. POAG – primary open angle glaucoma.

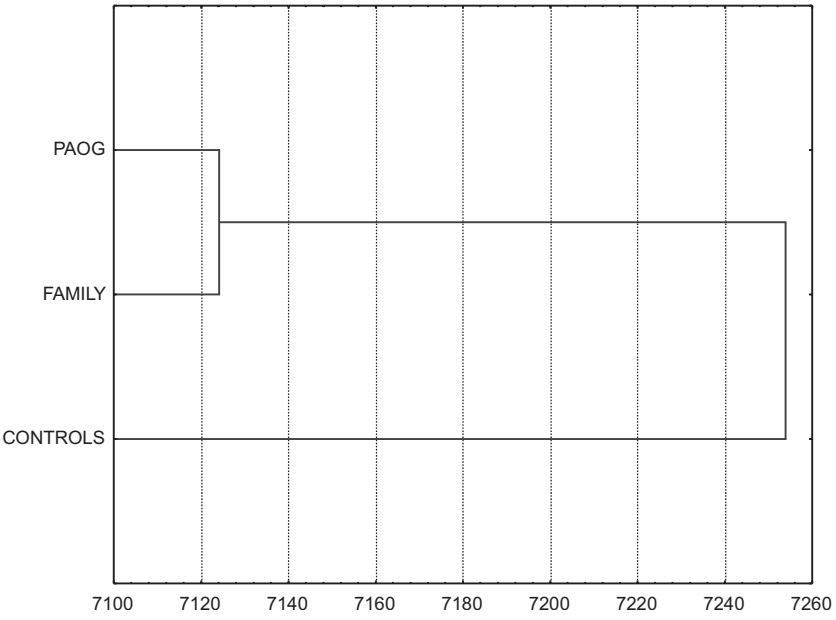

Fig. 2. Hiernaux Δg biological distances between female patients with PAOG, their immediate relatives, and controls. POAG – primary open angle glaucoma.

higher frequency of whorls. In acute blastocoels leukaemia, there has been greater frequency of arches and ulnar loops on fingers. In chronic lymphocyte leukaemia, there has been no change in dermatoglyphic traits, while in chronic myeloid leukaemia more whorls on fingers and in interdigital area III have been noticed[23]. On the samples of patients affected by carcinoma of different organs, lower number of arches, more whorls and lower number or radial loops on hand fingers have been noticed[24]. In patients with chronic polyarthritis, there have been differences in dermatoglyphic patterns of the hypothenar[25]. In patients with ankylosing spondylitis, there has been greater frequency of loops in interdigital areas I and II, and lower frequency of loops on the hypothenar[26]. In autistic boys, ulnar loops have been more frequent than whorls, while in autistic girls, whorls and arches have been more frequent than loops.

In this study of qualitative dermatoglyphic traits of the digito-palmar complex relative frequencies of arches on fingers are the greatest in males (5.5%), but that is

not the case with female patients (4.4%). In females, phenotypically healthy population (10.9%) has the greatest number of arches. Ulnar loops have the greatest percentage on fingers, but in all three male groups they are under 60%, which is typical for healthy population. However, in females affected by POAG, the relative frequency is 63%, while in their family members the frequency is even greater and it is more than 77.0%. In phenotypically healthy population, the relative frequency is 55.9%. The frequency of whorls on fingers have been lower in males affected by POAG (30.0%) than in male control groups, while in females the frequency of whorls on fingers have been lower than in those affected by the disease (22.6%) compared to phenotypically healthy population (30.0%). Female family members had the lowest relative frequency of whorls on fingers (13.5%). Relative frequency of patterns on the palm, namely in II and III interdigital area, has been lower in patients with POAG (2.3% and 6.8%) than in phenotypically healthy population (7.7% and 13.5%), while relative frequency of patterns on the thenar and hypothenar has been greater in those affected by the disease (15.1% and 47.7%) than in phenotypically healthy population (12.5% and 26.0%). In healthy females, greater relative frequency of patterns on the thenar has been proved (5.4%) only in II interdigital area, compared to those affected by glaucoma (4.3%). Greater frequency of patterns on the thenar in female patients (6.5%) than in their family members (2.2%) has been noticed, but the frequency has been even greater in phenotypically healthy population (8.7%). In females, as well as in males, the lowest frequency of patterns on the hypothenar has been found in female patients (26.1%), while in their family members (34.8%) or phenotypically healthy population (33.0%).

In all groups that have been examined, the most frequent has been the position of axial triradius on t, which has been the most frequent case in healthy population.

By estimating biological distances according to Hiernaux[22] Δg, it has been showed that there are similarities between the group of male patients affected by POAG and their immediate family members (Figure 1) and females (Figure 2), which can be classified into a special cluster compared with healthy male, namely female population. Male and female patients affected by POAG have been biologically closer to their immediate relatives than to phenotypically healthy population. The existence of similarities between patients and their immediate relatives has partly been caused by the fact that examined persons have been mainly parents and their children, and according to Fisher, the theoretical value of the correlation coefficient has been $r=0.5$ between parents and children[28]. The existence of similarities between those affected by POAG and their immediate relatives may be explained in the way that family members, who are affected by the disease, have the same genetic traits like their family members who are not affected by POAG, but these traits are different from those in healthy population.

Conclusion

In this study, differences in qualitative dermatoglyphic traits of the digito-palmar complex have been found between male and female groups examined (patients with POAG, their immediate relatives, and phenotypically healthy population) like manifestation traits.

Relative frequencies of patterns on fingers have been different in the group of patients with POAG than in the group of phenotypically healthy population for dermatoglyphic traits in both males and females. Relative frequencies of patterns on the palm have been different in the group of patients with POAG than in phenotypically healthy population, but only on the hypothenar. Relative frequencies of patterns on the palm between females patient with POAG and phenotypically healthy population have not been different. Frequencies of axial triradius on the palm have showed differences between groups of those affected by POAG and phenotypically healthy population in males, while frequencies of axial triradius on the palm between groups of patients with POAG and phenotypically healthy population in females have not been different.

The frequency of dermatoglyphic patterns on fingers has been different in the group of immediate relatives than in the group of patients with POAG and healthy male population. In females, the group of immediate relatives has not been different from the group of those affected by the disease. The frequency of certain patterns on the palm have not discriminated the group of immediate relatives from other two groups of both males and females. The position of axial triradius on the palm have discriminated the group of immediate relatives from phenotypically healthy population, but in the group of patients with POAG, only in males. By estimating the biological distances, it has been noticed that those affected by POAG and members of their families can be discriminated from phenotypically healthy population.

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ANALIZA KVALITATIVNIH SVOJSTAVA DERMATOGLIFA DIGITOPALMARNOG KOMPLEKSA U BOLESNIKA S PRIMARNIM GLAUKOMOM OTVORENOG KUTA

S A Ž E T A K

Primarni glaukom otvorenog kuta predstavlja grupu bolesti kojima su zajedničke karakteristične morfološke promjene na glavi vidnog živca i retinalnom sloju nervnih niti, progresivna smrt ganglijskih stanica i karakteristična oštećenja vidnog polja. Rizik pojave bolesti raste kontinuirano s visinom intraokularnog tlaka, a tijek je postepen i asimptomatski. Bolest je uzrokovana poremećajem odvoda sobne vodice u trabekularnom sustavu komoričnog kuta koji je otvoren. Etiopatogeneza primarnog glaukoma otvorenog kuta nije dovoljno jasna. Povećan rizik od pojave glaukoma kod bližih srodnika već dugo je poznat. Među srodnicima učestalost pojave glaukoma se kreće od 10–30%. Otkrića specifičnih genskih lokusa odgovornima za pojavu glaukoma doprinose razumijevanju mehanizma nastanka i svakako potvrđuje obiteljsko pojavljivanje ove bolesti. Digitopalmarni dermatoglifi su primjenjivani u procjeni nasljedne osnove mnogih bolesti, što je bio povod za ispitivanje kvalitativnih i kvantitativnih svojstava dermatoglifa digito-palmarnog kompleksa kod oboljelih od glaukoma (22 muškarca i 22 žene), bližih srodnika oboljelih (19 muškaraca i 23 žene) u odnosu na fenotipski zdravu populaciju (52 muškarca i 56 žena). Iz dobivenih rezultata utvrdila se povezanost svojstava dermatoglifa digito-palmarnog kompleksa kod glaukomskih bolesnika sa svojstvima dermatoglifa kod bližih neoboljelih srodnika. Također se utvrdila razlika po kojoj se oboljeli i njihovi bliži srodnici mogu diskriminirati od fenotipski zdrave populacije.