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# Comparing characteristics of the optic nerve head among subjects with suspected glaucoma in different ages of onset

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**SUMMARY**

**Introduction/Objective** Evaluation of the optic nerve head (ONH) is an inevitable procedure in the diagnosis of glaucoma. One of the most common imaging techniques for a quantitative assessment of the topography of the ONH is the Heidelberg retinal tomography II (HRT II).

The aim of this study was to determine quantitative stereometric parameters of the ONH by using HRT II and to investigate any damage of neuroretinal rim in children with suspected glaucoma and compare these data with a group of adults also with suspected glaucoma.

**Methods** This comparative study included 167 children (167 eyes) aged between five and 16 years (mean age of 11 ± 3 years) with suspected juvenile glaucoma and 175 adult participants (175 eyes), aged 55–66 years (mean age of 60 ± 3 years) also with suspected glaucoma. All of them were examined between January 2013 and April 2014. ONH topography and retinal nerve fiber layer thickness measurements were assessed using HRT II.

**Results** Data analysis in this study showed that the average mean values for children/adults were as follows: disc area ($mm^2$) 2.828 ± 0.489 / 2.663 ± 0.412 ($p < 0.001$); rim area ($mm^2$) 1.873 ± 0.391 / 1.667 ± 0.275 ($p < 0.001$); cup/disc area ratio 0.369 ± 0.125 / 0.369 ± 0.101 ($p = 0.530$); mean retinal nerve fiber layer thickness (mm) 0.223 ± 0.078 / 0.219 ± 0.055 ($p = 0.494$). Statistically significant difference in damage of neuroretinal rim, between children and adults, was found in the temporal and temporal-inferior segments.

**Conclusion** There were differences in some of the investigated quantitative parameters of the ONH between children and adults, as optic disc size, cup and rim area, and rim volume. By using Moorfields regression analysis, differences in the damage of the neuroretinal rim, when comparing children and adult optic discs, appeared only in the temporal and temporal-inferior segments, which means that optic disc cupping has spread more in the children than in the adults.

**Keywords:** Heidelberg retina tomography; optic disc; stereometric parameters; primary open angle glaucoma; juvenile glaucoma

## INTRODUCTION

Evaluation of the optic nerve head (ONH) is an inevitable procedure in the diagnosis of juvenile glaucoma. However, it is not easy to detect the first glaucomatous changes on a disc because of the great variability in the appearance of the optic nerve that often makes an accurate distinction between glaucomatous and healthy optic nerve rather difficult [1, 2]. On the other hand, the problems in the diagnosis of juvenile glaucoma are usually difficult in getting useful visual field information in children (especially young children). In the absence of a reliable visual field result, ophthalmologists must rely on an evaluation of structural changes on the optic disc, which according to the reported results, may precede the development of the reproducible perimetry defects by several years [3, 4, 5]. A confocal scanning laser tomography, Heidelberg retina tomography (HRT; Heidelberg Engineering, Heidelberg, Germany), is one of the promising tools for the evaluation of the ONH in glaucoma patients due to high reproducibility and ability to measure three-dimensional parameters [6, 7]. HRT has been used in recent years to perform quantitative measurements of the ONH and provides measures of ONH topography [8]. It has been proved to be highly reproducible and also shows good agreement with clinical estimates between ONH structure and visual function [9, 10, 11].

Glaucoma has been categorized by the age of onset and the angle characteristics. It is accepted to a certain extent that juvenile-onset primary open-angle glaucoma (JOAG) is a subset of adult primary open-angle glaucoma (POAG) with an earlier age of onset. However, JOAG and POAG differ from each other with regard to their inheritance, prevalence, and severity of presentation [12]. There is a lack of papers on comparative morphometric analysis of the ONH using confocal scanning laser ophthalmoscopy among primary open-angle glaucoma and juvenile-onset primary open-angle glaucoma, or their suspects.

The aim of this study was to determine quantitative stereometric parameters of the ONH by using Heidelberg retina tomography II (HRT II)

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and to investigate any damage of neuroretinal rim in children with suspected glaucoma and compare these data with the group of adults also with suspected glaucoma.

## METHODS

This prospective comparative study included 167 children (167 eyes) aged 5–16 years (mean age of 11 ± 3 years) with suspected juvenile glaucoma and 175 adult participants (175 eyes), aged 55–66 years (mean age of 60 ± 3 years) also with suspected glaucoma. All of them were examined between January 2013 and April 2014 at the Clinic for Eye Diseases, Clinical Center of Serbia, Belgrade. All subjects underwent a complete ophthalmic examination by a glaucoma specialist including visual acuity (Snellen chart), slit-lamp biomicroscopy, gonioscopy, IOP measurement with Goldmann applanation tonometry, and fundus examination using indirect ophthalmoscopy with Volk Superfield lens 90D. Diagnostic observation also included a visual field test using the Threshold C 24-2 Swedish Interactive Testing Algorithm (SITA) standard program with Humphrey visual field analyzer II (Carl Zeiss, Oberkochen, Germany) and scanning laser ophthalmoscopy – HRT II (version 2.02; Heidelberg Engineering, GmbH, Dossenheim, Germany). Central corneal thickness values were measured by ultrasonic pachymeter (Alcon Laboratories, OcuScan® RxP Ophthalmic Ultrasound system, Fort Worth, TX, USA) by trained ophthalmic technicians. The pachymetry measurement recorded for each eye was the average of three measurements taken per eye. Refractive error was measured with KR-7000 auto kerato-refractometer (Topcon, Tokyo, Japan) and was calculated as spherical equivalent in diopters (D), as the sum of the sphere and half of the refractive astigmatism.

Subjects included in the study were glaucoma suspects with either glaucomatous-appearing optic disc and IOP under 22 mmHg or healthy appearing optic disc and IOP of 22 mmHg or above. The criteria for determining the glaucomatous-appearing optic disc were assessed by the clinical impression of a glaucoma specialist. "Glaucomatous-appearing optic disc" must include one or more of the following: 1) excavation – undermining of the neuroretinal rim; 2) notching – it was considered if it involved two clock hours; 3) focal or diffuse atrophy of neuroretinal rim area – neuroretinal rim thinning involving two or more clock hours; 4) vertical cup-disc ratio of more than 0.6 or 5) vertical cup-disc asymmetry between the eyes of 0.2 or more [1]. Participants included in the study did not receive anti-glaucoma medications nor did they undergo surgery.

Inclusion criteria were as follows: 1) best-corrected visual acuity better than 0.8; 2) spherical refraction within ±5.0 D; 3) cylindrical correction within ±1.5 D; 4) open angle on gonioscopy, and 5) normal visual field.

Exclusion criteria were the coexistence of any other ophthalmic pathology other than glaucoma and IOP above 26 mmHg.

All subjects received a detailed explanation about the study and signed an informed consent form in accordance with the principles embodied in the Declaration of Helsinki. An informed consent to participate in the study was taken from all adult participants or from the guardians (if participants were below 18 years of age). The Ethics Committee of the Clinical Center of Serbia, where the study was undertaken, approved this study.

Study participants underwent ocular imaging with the commercially available HRT II version 2.02. HRT is a confocal scanning laser ophthalmoscope that provides software-generated measurements describing the topography of the surface of the optic disc and adjacent peripapillary retina. The right eye of each participant selected for the study was examined for the first time by means of HRT II. The same observer analyzed all HRT images after proper adjustment for refractive error and astigmatism.

Twelve stereometric parameters [disc area ($mm^2$), cup area ($mm^2$), rim area ($mm^2$), cup-to-disc area ratio (C/D ratio), cup volume ($mm^3$), rim volume ($mm^3$), mean retinal nerve fiber layer (RNFL) thickness, RNFL cross sectional, height variation contour (mm), mean cup depth (mm) and maximum cup depth (mm), and cup shape measure (mm)] of children and adults have been taken into consideration in this study. We also investigated data for the mean RNFL thickness, rim area, rim volume and C/D ratio in each of the six segments (temporal, temporal-inferior, temporal-superior, nasal, nasal-superior, and nasal-inferior).

Moorfields regression analysis (MRA) is a part of the HRT program, which represents the method for analyzing regression logarithmic of the global and six segment rim areas (temporal, temporal-inferior, temporal-superior, nasal, nasal-superior, and nasal-inferior) to the matching disc areas and compares the results to a normative database. It defines these areas as damaged or outside normal limit, borderline, and normal based on the 95% and 99.9% confidence intervals (CI): "normal" if all of the measurements fall within the 95% CI) "borderline" if at least one falls between the lower 95% and 99.9% CI; and "outside normal limits" if at least one rim area measurement is less than the lower 99.9% CI.

By using the MRA, the percentage of the participants who had normal, borderline, and/or outside normal limit neuroretinal rim (temporal, temporal-superior, temporal-inferior, nasal, nasal-superior, and nasal-inferior) was determined, so these data were compared between children and adult groups.

### Statistical analysis

Standard descriptive statistics were used. Student's t-test and Mann–Whitney test was used for comparison of the variables between studied groups; $\chi^2$ test was used to evaluate the significance of the differences between categorized data. Individual differences were considered to be statistically significant for $p < 0.05$. IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA) was used for all statistical calculations.

## RESULTS

During the observation period, 167 children and 175 adults were enrolled in this study. Baseline demographic characteristics of enrolled participants, IOP, best-corrected visual acuity, and refractive error in diopter are shown in Table 1.

The mean children's age was 11.2 ± 3.1 years (range of 5–16 years); the children were predominantly male (54%). In the adult group the mean age was 60.1 ± 3.2 years (range of 55–65 years); they were predominantly female (66%). The children's mean IOP was 16.5 ± 3.1 mmHg (range of 10–25 mmHg) and in the adults it was 19.7 ± 2.8 mmHg (range of 12–26 mmHg) (p = 0.584). There was a statistically significant difference in mean central corneal thickness in two studied groups, children/adults: 578 ± 35 μm (range of 503–620 μm) / 547 ± 35 μm (range of 453–60 μm) (p = 0.032). Visual acuity in both children and adults were 0.8 or better. They were predominantly myopic and spherical equivalent in children ranged between –5.00 and +1.00 D and in adults between -4.50 and +2.00 D.

Summary statistics for the optic disc morphometric characteristics of interest are presented in Tables 2, 3, 4, 5, and 6.

These summary statistics include the range, the mean, and standard deviation for each characteristic in each group. Table 2 shows a comparison of global ONH parameters by HRT II between the two groups. There were statistically significant differences between the children and the adults in the following stereometric parameters: disc area ($mm^2$): 2.828 ± 0.489 vs. 2.663 ± 0.412, (p < 0.001), cup area ($mm^2$): 1.157 ± 0.527 vs. 1.011 ± 0.381 (p = 0.0024), rim area ($mm^2$): 1.873 ± 0.391 vs. 1.667 ± 0.275 (p < 0.001), rim volume ($mm^3$: 0.437 ± 0.196 vs. 0.382 ± 0.132 (p = 0.039) and RNFL cross sectional 1.357 ± 0.473 vs. 1.262 ± 0.327 (p = 0.048). However, no significant differences were found in the mean C/D ratio, cup volume, mean RNFL, mean and maximum cup depth (p > 0.05).

We further analyzed C/D ratio, rim area, rim volume, and mean RNFL in each segment. Values of C/D area ratio in each of the six segments in both studied groups are summarized in Table 3. In temporal, temporal-inferior, nasal, and nasal-superior segments C/D ratio was larger in the children than in the adult group; with it, there were statistically significant differences in the temporal [0.592 ± 0.106 vs. 0.543 ± 0.146 (p = 0.044)] and the temporal-inferior [0.388 ± 0.122 vs. 0.349 ± 0.144 (p = 0.045)] segments. Rim area was larger in each of the six segments in children than in adults (Table 4) and statistically significant in all segments. Also, rim volume was greater in all segments in children than in adults, but it was statistically significant in temporal (p = 0.006), temporal-inferior (p < 0.001), and nasal (p = 0.0026) segments (Table 5). Analyzing the mean RNFL we did not find statistically significant differences in each of the 6 segments between two studied groups (Table 6).

By analyzing the MRA findings of both groups, statistically significant difference between children and adults in damage of neuroretinal rim was found in the temporal (p < 0.001) and the temporal-inferior segment (p = 0.0046) (Table 7).

Data for the temporal segment for children/adults were (in percent) normal (77.2/96.1%), borderline (21.3/3.9%), outside normal limit (1.6/0%); for the temporal-inferior

**Table 1.** Characteristics of the participants in both studied groups

| Variables | Children | Adults | p |
|---|---|---|---|
| Number of participants, n | 167 | 175 | |
| Male / female, n (%) | 90 (54) / 77 (46) | 59 (34) / 116 (66) | 0.001 |
| Age (years), mean ± SD (range) | 11.2 ± 3.1 (5–16) | 60.1 ± 3.2 (55–65) | < 0.001 |
| IOP (mmHg) (range) | 16.5 ± 3.1 (10–25) | 19.7 ± 2.8 (12–26) | 0.584 |
| CCT (μm), mean ± SD (range) | 578 ± 35 (503–620) | 547 ± 35 (453–601) | 0.032 |
| Best corrected VA (range) | 0.98 ± 0.048 (0.8–1.0) | 0.98 ± 0.027 (0.8–1.0) | 0.755 |
| Refractive error, SE (D), (range) | -2.50 (-5.00–+1.00) | -1.50 (-4.50–+2.00) | 0.313 |

IOP – intraocular pressure; VA – visual activity; SE – spherical equivalent; D – diopter; CCT – central corneal thickness

**Table 2.** Values of global optic nerve head parameters in both studied groups

| Stereometric parameters | Children | | Adults | | p |
|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | |
| Disc area ($mm^2$) | 1.685–4.571 | 2.828 ± 0.489 | 1.780–3.745 | 2.663 ± 0.412 | < 0.001 |
| Cup area ($mm^2$) | 0.042–2.758 | 1.157 ± 0.527 | 0.187–1.957 | 1.011 ± 0.381 | 0.0024 |
| Rim area ($mm^2$) | 1.873–3.593 | 1.873 ± 0.391 | 0.908–2.630 | 1.667 ± 0.275 | < 0.001 |
| Cup/disc area ratio | 0.021–0.639 | 0.369 ± 0.125 | 0.081–0.599 | 0.369 ± 0.101 | 0.530 |
| Cup volume ($mm^3$) | 0.001–1.122 | 0.387 ± 0.262 | 0.028–1.078 | 0.327 ± 0.203 | 0.065 |
| Rim volume ($mm^3$) | 0.123–1.343 | 0.437 ± 0.196 | 0.127–0.850 | 0.382 ± 0.132 | 0.039 |
| mRNFL | 0.052–0.467 | 0.223 ± 0.078 | 0.091–0.398 | 0.219 ± 0.055 | 0.494 |
| RNFL cross section ($mm^2$) | 0.034–2.873 | 1.357 ± 0.473 | 0.522–2.190 | 1.262 ± 0.327 | 0.048 |
| Mean cup depth (mm) | 0.074–0.677 | 0.307 ± 0.096 | 0.111–0.631 | 0.309 ± 0.098 | 0.889 |
| Maximum cup depth (mm) | 0.200–1.316 | 0.744 ± 0.181 | 0.379–1.278 | 0.758 ± 0.180 | 0.552 |
| Height variation contour | 0.171–1.553 | 0.370 ± 0.149 | 0.183–0.655 | 0.356 ± 0.081 | 0.706 |
| Cup shape measure | -0.412–0.058 | -0.144 ± 0.078 | -0.309–0.048 | -0.152 ± 0.081 | 0.264 |

mRNFL – mean retinal nerve filter layer

**Table 3.** Values of cup-to-disc area ratio in each of the six segments in both studied groups

| Cup-to-disc area ratio segments | Children | | Adults | | p |
|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | |
| Temporal | 0.081–0.864 | 0.592 ± 0.106 | 0.230–0.822 | 0.543 ± 0.146 | 0.044 |
| Temporal-superior | 0.000–0.724 | 0.408 ± 0.133 | 0.069–0.704 | 0.430 ± 0.123 | 0.133 |
| Temporal-inferior | 0.010–0.813 | 0.388 ± 0.122 | 0.007–0.737 | 0.349 ± 0.144 | 0.045 |
| Nasal | 0.000–0.738 | 0.239 ± 0.162 | 0.000–0.680 | 0.218 ± 0.149 | 0.084 |
| Nasal-superior | 0.000–0.636 | 0.317 ± 0.154 | 0.000–0.588 | 0.303 ± 0.135 | 0.588 |
| Nasal-inferior | 0.000–0.524 | 0.207 ± 0.124 | 0.000–0.662 | 0.219 ± 0.128 | 0.686 |

**Table 4.** Values of rim area in each of the six segments in both studied groups

| Rim area segments | Children | | Adults | | p |
|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | |
| Temporal | 0.081–0.651 | 0.301 ± 0.096 | 0.087–0.464 | 0.265 ± 0.069 | < 0.001 |
| Temporal-superior | 0.103- 0.443 | 0.257 ± 0.063 | 0.079–0.326 | 0.233 ± 0.043 | < 0.001 |
| Temporal-inferior | 0.076–0.650 | 0.257 ± 0.071 | 0.058–0.345 | 0.214 ± 0.043 | < 0.001 |
| Nasal | 0.199–1.086 | 0.545 ± 0.133 | 0.206–1.021 | 0.510 ± 0.106 | 0.022 |
| Nasal-superior | 0.069–0.555 | 0.257 ± 0.154 | 0.141–0.334 | 0.233 ± 0.430 | < 0.001 |
| Nasal-inferior | 0.168–0.554 | 0.292 ± 0.065 | 0.123–0.446 | 0.255 ± 0.053 | < 0.001 |

**Table 5.** Values of rim volume in each of the six segments in both studied groups

| Rim volume segments | Children | | Adults | | p |
|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | |
| Temporal | 0.010–0.100 | 0.029 ± 0.016 | 0.000–0.080 | 0.024 ± 0.012 | 0.006 |
| Temporal-superior | 0.008–0.131 | 0.049 ± 0.023 | 0.008–0.126 | 0.045 ± 0.019 | 0.211 |
| Temporal-inferior | 0.006–0.259 | 0.061 ± 0.033 | 0.010–0.134 | 0.048 ± 0.021 | < 0.001 |
| Nasal | 0.000–0.272 | 0.063 ± 0.059 | 0.000–0.237 | 0.044 ± 0.046 | 0.144 |
| Nasal-superior | 0.004–0.253 | 0.066 ± 0.036 | 0.015–0.167 | 0.064 ± 0.026 | 0.927 |
| Nasal-inferior | 0.024–0.268 | 0.091 ± 0.039 | 0.018–0.175 | 0.078 ± 0.030 | 0.0026 |

**Table 6.** Values of the mean retinal nerve filter layer (mRNFL) in each of the six segments in both studied groups

| mRNFL segments | Children | | Adults | | p |
|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | |
| Temporal | 0.096–0.168 | 0.079 ± 0.030 | 0.038–0.142 | 0.075 ± 0.020 | 0.114 |
| Temporal-superior | 0.021–0.493 | 0.252 ± 0.088 | 0.104–0.501 | 0.262 ± 0.077 | 0.526 |
| Temporal-inferior | 0.024–0.628 | 0.265 ± 0.107 | 0.055–0.453 | 0.242 ± 0.082 | 0.706 |
| Nasal | 0.050–0.700 | 0.246 ± 0.113 | 0.030–0.460 | 0.233 ± 0.079 | 0.059 |
| Nasal-superior | 0.198–0.615 | 0.284 ± 0.122 | 0.089–0.569 | 0.303 ± 0.088 | 0.258 |
| Nasal-inferior | 0.109–0.648 | 0.330 ± 0.110 | 0.137–0.512 | 0.323 ± 0.083 | 0.474 |

**Table 7.** Moorfields regression analysis results

| Segments (%) | Children | | | Adults | | | p |
|---|---|---|---|---|---|---|---|
| | IN | BL | OUT | IN | BL | OUT | |
| Temporal | 98 (77.2) | 27 (21.3) | 2 (1.6) | 122 (96.1) | 5 (3.9) | 0 (0) | < 0.001 |
| Temporal-superior | 119 (93.7) | 6 (4.7) | 2 (1.6) | 114 (89.8) | 12 (9.4) | 1 (0.8) | 0.2695 |
| Temporal-inferior | 101 (79.5) | 21 (16.5) | 5 (3.9) | 117 (92.1) | 9 (7.1) | 1 (0.8) | 0.0046 |
| Nasal | 93 (73.2) | 21 (16.5) | 13 (10.2) | 106 (83.5) | 13 (10.2) | 8 (6.3) | 0.1498 |
| Nasal-superior | 95 (74.8) | 23 (18.1) | 9 (7.1) | 95 (74.8) | 29 (22.8) | 3 (2.4) | 0.8285 |
| Nasal-inferior | 105 (82.7) | 14 (11) | 8 (6.3) | 105 (82.7) | 13 (10.2) | 9 (7.1) | 0.9772 |

IN – normal; BL – borderline; OUT – outside normal limit

segment they were normal (79.5/92.1%), borderline (16.5/7.1%), and outside normal limit (3.9/0.8%). There was no statistically significant difference in other segments.

## DISSCUSION

In the present study, we evaluated stereometric parameters of the ONH in suspected primary open-angle glaucoma in different ages of onset. Our first purpose was to evaluate morphometric features of the optic disc in children, and the second one was to compare these data with the data of the group of adults. The optic disc characteristics have been extensively studied with regard to adult onset of POAG, but there are few studies relating to the morphometry of primary juvenile glaucoma discs [13, 14]. On the other hand, HRT has been used in normal children in a few studies [15–18]. Ruberto et al. [15] reported normal values for HRT in comparison with children with cerebral visual impairment, and Tong et al. [16] presented values of myopic 11–12-year-old Singaporean children. Recently, He et al. [17] used HRT to analyze disc and cup area in a twin

study of children. Larsson et al. [18] investigated the normal values but also repeatability and interocular difference of the ONH, using HRT, in 5–16-year-old full term children. They had smaller disc area than in the present study (2.16 $mm^2$ vs. 2.83 $mm^2$), as well as rim area (1.75 $mm^2$ vs. 1.87 $mm^2$) and cup area (0.41 $mm^2$ versus 1.15 $mm^2$). Chinese twins, studied by He et al. [17], also had smaller disc area [2.83 $mm^2$ (present study) vs. 1.97 $mm^2$] and smaller cup area [1.15 $mm^2$ (present study) vs. 0.50 $mm^2$]. The differences were obvious especially in the cup area because in our study most of the children had a glaucomatous-appearance disc and Larsson et al. [18] and He and al. [17] studied normal children. Also, the reason for large discs and large cupping could be the reason why children in our study had myopic refractive errors like in the study by Jung et al. [19], in which they suggested that highly hyperopic eyes have significantly smaller optic discs and highly myopic eyes have significantly larger discs than emmetropic eyes.

There were not many studies on comparative morphometric analyses of ONH using confocal scanning laser ophthalmoscopy among primary glaucoma in different ages of onset. Jonas and Grundler [13] compared ONH between JOAG and POAG patients in 1996, and recently Gupta et al. [12] analyzed differences in optic disc characteristics between primary congenital glaucoma, juvenile, and adult onset open angle glaucoma patients.

The present study found optic discs to be larger among patients with suspected JOAG compared with suspected glaucoma in adults. Our parameters were larger than in the recent study by Gupta et al. [12] – optic disc size in JOAG patiens was 2.61 $mm^2$ vs. 2.83 $mm^2$ (present study); the parameters were also significantly larger than in adult POAG eyes [2.44 $mm^2$ vs. 2.663 $mm^2$ (present study)]. It can be observed that in the study by Gupta et al. [12] the patients were presenting with a confirmed diagnosis of glaucoma, while in our study participants were presenting with suspected glaucoma. One of explanations that children may have larger optic disc sizes might be that a larger disc size may also be inherited with a genetic susceptibility to develop glaucoma. It is known that genetic susceptibility plays a greater role in the causation of glaucoma in children (congenital and juvenile) compared to adults, where causation is, more often, multifactorial. Hence, genetic segregation of children affected by glaucoma could also account for the larger optic discs seen within our observations of these young participants compared with our adult participants [20].

On other hand, Jonas and Grundler [13] studied the optic disc morphometry of 37 JOAG and 382 adult POAG patients using stereo disc photographs but did not find a difference in the disc area between the juvenile and adult onset POAG eyes in their population. They used the planimetric method for calculations, which is known to give larger measurements because of image magnification compared with the confocal scanning laser ophthalmoscope (CSLO).

Measurement of the optic disc and neuroretinal rim is important for the diagnosis and management of glaucoma [21]. It is increasingly recognized that the disc size is a major determinant of other disc parameters such as neuroretinal rim area or cup area or volume [13, 19, 22]. When comparing our data compiled from the children and the adults groups, in addition to larger disc sizes, the children also had larger rim areas, which is consistent with the results in previous published studies [23, 24].

In our study, children also had greater average cup area and cup volume than adults. Jonas and Grundler [13] also found that cup volume in children with JOAG were larger than in POAG patients. In the study by Gupta et al. [12], the cup characteristics demonstrated significantly greater means among JOAG compared with POAG and primary congenital glaucoma eyes, including cup depth ($p = 0.001$), cup volume ($p = 0.024$), and C/D area ratio ($p = 0.049$). C/D ratio as a measure for determining structural change is most often used clinically by glaucoma specialists to assess structural damage of the optic disc. In the present study there was no significant difference in the mean C/D ratio between children and adults (children $0.369 \pm 0.125$, adults $0.369 \pm 0.101$).

We mentioned that previous studies have suggested a correlation of neuroretinal rim area and optic cup area to the optic disc size but the question is the correlation between disc size and RNFL [13, 19, 22]. Budenz et al. [25] have demonstrated thicker RNFL in larger optic discs. In our study, RNFL was thinner in adults but we need to take into consideration the fact that age is recognized as a significant factor affecting RNFL thickness [26, 27], and that normal individuals lose ganglion cells in an age-dependent manner, at an estimated rate of up to 5,000 axons/year, which may translate into considerable axon loss during a 70-year life span [24]. On the other hand, our results coincide with results in a study by Savini et al. [22], showing that RNFL thickness was positively correlated with ONH size. Such a correlation may be the result of either an increased number of nerve fibres in eyes with larger discs or a smaller distance between the circular scan and the true ONH margin [22].

Besides quantitative parameters of the ONH in children and adults, we investigated differences in damage of the neuroretinal rim with MRA, comparing children's and adult optic discs in which damage was only appearing in the temporal and temporal-inferior segments; our conclusion is that the optic disc cupping spread more in children than in adults. MRA indicates normal, borderline, and outside normal limits on the basis of a comparison between an examined optic disc and a dedicated database of normal eyes and is highly capable of clinically discriminating normal and glaucomatous patients. In our study, there was a statistically significant difference of the percentage distribution in normal, borderline, and outside normal limit between children and adults group in the temporal and temporal-inferior segments; in these segments neuroretinal rim was more damaged in children than in adults. Several clinical studies support the idea that damage to the optic nerve and the RNFL can be identified before an alteration in the visual field [28]. This fact is very important in the examination of children, because determination of the visual field and interpretation of the results

may prove challenging. Detection and monitoring of glaucoma patients are based on identification of structural and functional changes. We mentioned that in the absence of reliable visual field results in children, ophthalmologists must rely on evaluating structural changes on the optic disc. We also know that structural alterations of the optic disc nerve fiber layer complex provide the earliest reliable signs of damage from glaucoma [24, 29]. Accurate and objective quantitative measurements of the ONH and nerve fiber layer are required to improve our ability to regularly recognize early glaucomatous damage. It follows that it is important to evaluate the ONH by using well-established confocal scanning laser ophthalmoscope, HRT II, and to improve detection of early damage [30]. Also, HRT is a quick and non-invasive technique and therefore is applicable in children.

Our study has some limitations. While HRT has mostly been used in the diagnosis of glaucoma, it has also been the requirement that the operator manually defines a contour line marking the inner border of the ONH margin as defined by the sclera ring. Many of the quantitative measurements are derived from the contour line placement, thereby inducing measurement variability. Second, the problem is that there is a lack of normative database for subjects under the age of 18 and consequently HRT use in children has not been extensively studied. Also, it should be noted that the mean age of these two groups was different, which makes the comparison less accurate. We did not present age-matched control data because the aim of this study was to compare morphologic appearance of optic disc in glaucoma suspects in different ages of onset. In addition, it should be taken into account that all the participants underwent visual field testing with a limitation, which implies that most of the children did not have reliable visual field testing results. Finally, it is important to highlight that participants with suspected glaucoma were enrolled in the study. Even though JOAG is, by definition, characterized by elevated IOP, in the clinical practice, most children with suspected JOAG have glaucomatous-appearing optic disc with IOP in the normal range and therefore a certain number of these children were included in the study.

## CONCLUSION

The results of the present study showed that there were differences in some of the investigated quantitative parameters of the ONH between children and adults, such as optic disc size, cup and rim area, and rim volume. When comparing children's and adult optic discs by using MRA, the difference in the damage of the neuroretinal rim appeared only in the temporal and temporal-inferior segments, which means that optic disc cupping spread more in children than in adults.

Diagnosis of glaucoma in children remains a challenge for clinicians. The assessment of the optic disc and peripapillary RNFL damage in pediatric subjects can be quite challenging; visual field testing in young children is often especially unreliable or even impossible. Although diagnostic imaging methods lack a normative database for subjects under the age of 18 years and their use in children has not been extensively studied, the clinicians would appreciate support by objective methods to differentiate between normality and abnormality in borderline cases. Hence, the aim of this study was to give insight into the characteristics of the ONH in children with suspected glaucoma by using HRT and to underline the similarities and differences between children and adults with suspected glaucoma. Furthermore, we hope that it will be helpful in the diagnosis of glaucoma in children.

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## Топографска процена папиле видног живца код деце и одраслих са сумњом на глауком

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**САЖЕТАК**

**Увод/Циљ** Преглед папиле видног живца (ПВЖ) представља основу приликом постављања дијагнозе глаукома. Једна од најчешћих дијагностичких метода за квантитативну процену топографије ПВЖ је Хајделбергова томографија ретине II (ХТР II).

Циљ рада је био одредити помоћу ХТР II квантитативне стереометријске параметре папиле код деце са сумњом на јувенилни глауком и упоредити те параметре са групом одраслих особа такође са сумњом на глауком.

**Методе** У студију је укључено 167 деце узраста 11 ± 3 година са сумњом на јувенилни глауком и 175 одраслих старости 60 ± 3 година са сумњом на глауком у периоду од јануара 2013. до априла 2014.

Преглед ПВЖ и перипапиларне регије обављен је употребом ласер скенинг томографа ХРТ II.

**Резултати** Просечне вредности стереометријских параметара код деце/одраслих биле су: површина ПВЖ ($mm^2$) 2,828 ± 0,489 / 2,663 ± 0,412 ($p < 0,001$); површина неуроретиналног обода ($mm^2$) 1,873 ± 0,391 / 1,667 ± 0,275 ($p < 0,001$); однос пречника екскавације и пречника папиле 0,369 ± 0,125/ 0,369 ± 0,101 ($p = 0,530$); просечна дебљина слоја нервних влакана 0,223 ± 0,078 / 0,219 ± 0,055 *mm* ($p = 0,494$). Оштећење неуроретиналног обода показало је статистичку значајност у темпоралном и темпоралнодоњем сегменту код деце у односу на одрасле испитанике.

**Закључак** У овој студији постојала је разлика у вредностима неких од стереометријских квантитативних параметара ПВЖ између деце и одраслих, као што су: површина ПВЖ, површина и запремина неуроретиналног обода. Неуроретинални обод је био ужи у темпоралном и темпоралнодоњем сегменту код деце, тј. више се ширила глаукоматозна екскавација.

**Кључне речи:** Хајделбергова ретинална томографија; глава оптичког нерва; стереометријски параметри; примарни глауком отвореног угла; јувенилни глауком