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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

**GEORGIAN MEDICAL NEWS**

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**GMN: Georgian Medical News** is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

**GMN: Медицинские новости Грузии -** ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

**GMN: Georgian Medical News –** საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

**WEBSITE**

www.geomednews.com

## К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

**При нарушении указанных правил статьи не рассматриваются**.

## REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.**

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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*Содержание:*

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# STUDY OF ORBITAL NEOPLASMS BY MAGNETIC RESONANCE IMAGING PROCEDURE

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## Abstract.

The neoplasms of the organ of vision are characterized by significant polymorphism, which is due to the histological diversity of the structures in the eye socket. Almost all types of neoplasms described in humans are found in the orbit. The study aimed to determine the diagnostic value of magnetic resonance imaging in patients with tumors in the eyeball and the eye socket, as well as to determine the superiority of the MRI procedure compared to other instrumental methods of research.

The paper presents the results of the study of 67 patients with pathological processes of the orbit, whose ages ranged from a few months to 81 years. Of them, 23 (34.3%) were men and 44 (65.7%) were women. Magnetic resonance imaging was performed on a Siemens MAGNETOM Vida 3T device in three projections.

As a result of the analysis of MRI semiotics of primary tumors of the orbit and eyeball, their common features were revealed: the predominance of oval-shaped tumors. Also, in most cases, the contours of the tumors were regular and clear. The structure of the pathological formation was homogenous. The heterogeneity of the structure of the tumors was revealed in 25.6% of cases, while in more than half of the patients, no additional inclusions were detected, and in the rest, the presence of areas of fat density and calcinates was determined.

During studies under intravenous bolus contrast with cyclolux and Gadovist, 62.8% showed an active high accumulation of contrast in the tumor, indicating a developed vascular network in the tumor formation.

Of all tissue imaging methods, the magnetic resonance imaging procedure provides the most complete pathoanatomical picture and allows for conducting non-invasive angiographic examination and obtaining diffusion, perfusion, and spectroscopy images.

**Key words.** Sagittal and axial slices, orbital neoplasms, intravenous bolus contrast, melanoma, cavernous hemangioma, adenoma of the lacrimal gland, lymphoma, retinoblastoma, menangioma, perfusion.

## Introduction.

Ophthalmo-oncology is among the most complex areas of ophthalmology. In recent years, there has been a growth tendency in the incidence, which is largely due to the wide availability and accessibility of early clinical and instrumental diagnostics. The statistics given in different sources of literature are quite contradictory. According to statistics, in 2007, the share of tumors of the organ of vision is 0.1% of all oncological diseases and 18% of all orbital diseases [1]. Taking into account the age group, the highest share of malignant tumors - 9.51 cases per 1 million inhabitants occurs in the population aged ≥50 years. In patients aged 0-19, the corresponding rate is 0.56 cases per 1 million inhabitants. The increase and diversity of oncological pathologies in ophthalmic oncology has led to the demand for differential diagnostics aimed at early detection of tumors and timely treatment [2].

Anatomic and topographic features of the orbital structure are due to its close connection with the structures of the skull and the paranasal sinuses, which indicates that there is a risk of possible dissemination of inflammatory and neoplastic processes from these areas to the orbit and retrogradely. The difficulty in diagnosing the pathology of the eyeball is not only with its anatomical structure, but also with the similarity of the clinical symptoms of many diseases of different etiologies (tumor, inflammatory, vascular, endocrine), whose radiological and clinical pictures are quite similar. Considering the above reasons, early detection and differentiation of orbital tumors and tumor-like formations remains one of the important challenges of diagnostic radiology [3,4].

The neoplasms of the organ of vision are characterized by significant polymorphism, which is due to the histological diversity of the structures in the eye socket. Almost all types of neoplasms described in humans can be found in the orbit [5]. In a retrospective study, which involved 2480 patients with orbital neoplasms, a 68% specific share of benign tumors was verified morpho-histologically, among which dermoid cysts (14%) and cavernous hemangiomas (9%) occupied the leading position [6,7].

In the practice of ophthalmology, the differential diagnosis of orbital tumors, as well as intraocular neoplasms, is still among the most responsible procedures. Regardless of the nature of the pathological process, neoplasms of the orbit often cause loss of visual function and disability in the patient. The loss of visual function in benign tumors and the threat to the patient's life in the case of malignant tumors of the orbit and eyeball substantiate the medical and social importance of early diagnosis and timely therapeutic measures.

## Materials and Methods.

The study was prospective and single-centric. The paper presents the results of the study of 67 patients with pathological processes of the orbit, whose ages ranged from a few months to 81 years. The study involved patients with only eyeball and orbital pathologies and those who were not burdened by other chronic diseases. Of them, 23 (34.3%) were men and 44 (65.7%) were women. The number of children from 0.5 to 18 years of age was 12 (17.9%), of which 7 (58.3%) were boys and 5 (41.7%) were girls. The highest number of patients were of active working age (41 to 60 years), and women were more numerous than men (65.7% and 34.3%, respectively). Table 1 presents data on the distribution of patients by gender and age.

*__Table 1.__ The distribution of patients by gender and age.*

| **Age, year** | | **0-10** | **10-50** | **50-70** | **>70** |
|---|---|---|---|---|---|
| **Number of studies** | **Men** | 2 (2,98 %) | 10 (14,92 %) | 11 (16,42 %) | 2 (2,98) |
| | **Women** | 3 (4,48 %) | 18 (26,87 %) | 18 (26,86 %) | 3 (4,49%) |
| **Total** | | 5 (7,46 %) | 28 (41,79%) | 29 (43,28%) | 5 (7,47%) |
| **Totally** | | 67 (100 %) | | | |

When analyzing data on the prevalence of orbital diseases in different age groups, it was determined that the maximum number of observations in both men and women falls on the fifth and sixth decades of life.

The largest group consisted of patients with primary neoplasms - 43 (64.2%). Secondary orbital tumors were detected in 24 (35.8%) patients. For all patients, morphological confirmation of the diagnosis was obtained according to the results of the cytological study of the biopsy or histological examination of the tumor removed during surgery.

Magnetic resonance imaging was performed on a Siemens MAGNETOM Vida 3T device in three projections.

This method is based on the measurement of the electromagnetic response of the nuclei of hydrogen atoms during their excitation by a certain combination of electromagnetic waves in a constant high-intensity magnetic field. The method allows for high differentiation of the orbit, paranasal sinuses, and the brain.

The studies were performed mostly in the axial plane, in parallel to the optic nerve. The scanning area included all orbital structures and the intracranial part of the optic nerves. In addition, for a more detailed evaluation of the contents of the retrobulbar space, we examined the orbital area in the sagittal and frontal planes. The thickness of the slices was 2-4 mm.

In order to differentiate orbital neoplasms, studies were conducted with sagittal and axial slices using T1tse, T2tse, tirm, GRE, and DWI modes. Additionally, to specifically evaluate intraorbital structures, the study was conducted with T1tse 2mm slices in the coronal and sagittal planes, T2tse coronal and axial slices with fs addition, that is, by fat suppression, and in T1tse slices with fat suppression for each eye separately. In order to study the orbital tumors in more detail, to determine their exact location and size, in the research process, intravenous injection of a contrast substance was performed, and then post-contrast T1 axial, coronal and sagittal slices were taken, the thickness of the slice is 2 mm. Ciclolux and Gadovist drugs were used as the contrast agents.

During the study, the patient lies on his back, and the head is placed centrally with respect to the gantry. A head and neck coil is applied to the patient's head and neck. In rare cases, a specialized eye socket coil (loop coil) is used, which is attached to the eye socket (Figures 1 and 2).

The condition of the orbital structures (optic nerve, extraocular muscles, retrobulbar fat) and the location of the eyeball were determined using the obtained MRI tomograms. At the same time, the state of the paranasal sinuses and the brain surrounding the orbit was evaluated on all tomograms and the spread of tumor formations in these spaces.


***Figure 1.** Specialized eye socket coil (loop coil).*

***Figure 2.** The head and neck coil.*

In our studies, along with standard MRI, we used diffusion and perfusion magnetic resonance methods with contrast enhancement, which allows us to more reliably distinguish between cancerous and non-cancerous processes and make a differentiated diagnosis of neoplasms in the orbit in the early stages.

## Literature review.

Magnetic resonance imaging (MRI) is one of the newest methods among radiological methods. Currently, MRI has significant advantages over CT. Magnetic resonance imaging can obtain a cross-sectional image of any part of the body with a high possibility of soft tissue differentiation. Also, the absence of ionizing radiation provides an additional advantage over other high-tech studies.

MRI tomograms are constructed by the re-emission of radio waves by hydrogen nuclei (protons) in the body's tissues after they receive energy from the radio wave signal that the MRI machine directs to the patient. Contrast in magnetic resonance imaging is determined by differences in the magnetic properties of tissues. Anatomical areas with a low number of protons, such as air-containing organs (lungs), always induce a very weak magnetic resonance signal and are therefore represented in black in the image. Water and other liquids that have a very high proton density are present at high intensities. However, this is not always the case. The reason for this phenomenon is that the contrast of the image is determined not only by the density of protons. Other parameters also play a part; two of them are the most important - relaxation times in T1 and T2 modes. T1 is the recovery time of longitudinal magnetization, while T2 – is that of transverse magnetization. In practice, they try to get an image that depends only on one of the relaxation times. These are known as Tl-(TIWI) or T2-(T2WI) weighted images. The use of this or that weighted image allows changing the contrast of tissues. For example, the vitreous body or cerebrospinal fluid is dark on a T1 image but bright on a T2 image. The acquisition of weighted images using a certain impulse sequence varies with both the relaxation time (TR) and the echo delay time (TE). The use of TlWI images provides good anatomical details, while the T2WI images are good for evaluating the pathological process (exception can be considered uveal pigmented melanoma, for which a high intensity signal is specific on the T1WI images). During MRI, it is possible to use the method of intravenous enhancement with the introduction of drugs based on gadolinium, which is especially important for the diagnosis of tumor processes. Tissue imaging can be obtained in three planes: axial, coronal, and sagittal, however, unlike computed tomography, where multiplanar reconstruction is used, each plane image is obtained independently in magnetic resonance imaging [8,9]. Non-contrast magnetic resonance angiography (MRA) is used to obtain images of vascular structures. MRA has a significant advantage - no contrast material is used during its performance, and the method is non-invasive, it can be performed during other, routine procedures. The basis of image acquisition is the registration of signals from stationary structures (tissues) and from structures moving at different speeds. The advantages of MRI are: 1. A particularly high contrast ability of tissues, which is not based on density, but on several parameters that depend on the physical and chemical properties of tissues, and visualization thanks to these changes, which are not differentiated during ultrasound and CT examination. 2. During intravenous contrast, it is possible to provide the imaging of not only the degree of vascularization but also the physical-chemical properties of tissues (using perfusion, spectroscopic, and other modes). 3. The absence of artifacts from bones, which often complicate differentiation (especially the structures of the posterior fossa) on CT. 4. MRI shows blood flow without artificial contrast due to the sensitivity of the simplest modes to movements. 5. MRI has led to a further reduction in the scope of invasive diagnostic studies, intravenous contrast during CT, and contrast X-ray studies. 6. The diagnostic capabilities of MRI are expanded by the use of paramagnetic contrast media as a result of intravenous contrast. The negative aspects of MRI are: 1. Unlike CT, the difficulty with differentiating calcified foci. 2. Magnetic resonance imaging is highly sensitive to dynamic and respiratory artifacts. 3. Long image acquisition time, which is often additional discomfort for the patient and the main cause of respiratory or movement artifacts. The presence of a cardiac pacemaker in the patient, foreign bodies in the orbit and skull cavity, and limb prostheses incompatible with magnetic resonance imaging is a contraindication, since the main risk of the study is the impact of magnetic fields on metal foreign bodies in the organism, as well as the impact of radio frequency fields on the implanted electronic devices.

Since primary malignant tumors of the orbit do not exceed 0.1% of all human malignant tumors, there are few publications regarding their computed tomography semiotics, which should be due to the active implementation of magnetic resonance imaging as a leading diagnostic tool in oncophthalmology [10-12].

Among the modern imaging tools, the high diagnostic role of magnetic resonance and positron emission tomography in the diagnosis and differential diagnosis of voluminous formations of the eye and eye socket can be noted. The use of magnetic resonance imaging modes such as T1WI, T2WI, FLAIR/STIR, post-contrast T1-weighted image with fat suppression, post-contrast perfusion study, DWI, and ADC maps in some cases allow not only the identification of the tumor but also study of its functional and morphological characteristics [2,13-16].

## Results.

The paper presents the results of the study of 67 patients with pathological processes of the orbit. Of them, primary orbital tumors were detected in 43 (64.2%) and secondary orbital tumors were detected in 24 (35.8%) patients.

The magnetic resonance imaging procedure was the final stage of differentiation of the diagnosis after preliminary clinical, ultrasonographic, and computed tomography examinations. The purpose of the study was to determine the differential diagnostic signs of orbital neoplasms of different origins and to detect the spread of the lesions to the surrounding tissues.

Magnetic resonance imaging examination involved 43 patients with primary neoplasms of the orbit and eyeball. While performing the examination, we evaluated the following parameters:

- Location of neoplasms
- Dimensions of the tumor
- The shape of the tumor
- Neoplasm structure
- Connection between the tumor and orbital structures

As a result of the analysis of MRI semiotics of primary tumors of the orbit and eyeball (Table 2), their common features were revealed: the predominance of oval-shaped tumors - 72.1%, tumors of the wrong shape were observed only in 27.9%.

Also, in most cases, the contours of the tumors were regular and clear, in 81.4% of cases, they were irregular and unclear only in 18.6% of cases.

***Table 2.*** *MRI signs of primary neoplasms of the orbit and eyeball.*

| MRI signs | | Primary neoplasms (n – 43) | |
|---|---|---|---|
| | | Abs. | % |
| Architectonics | Solitary | 41 | 95.3 |
| | Multi-node | 2 | 4.7 |
| Shape | Oval | 31 | 72.1 |
| | Irregular | 12 | 27.9 |
| Structure | Heterogeneous | 11 | 25.6 |
| | Homogeneous | 32 | 74.4 |
| Inclusions | Calcined inclusions | 3 | 7.0 |
| | Fat density inclusions | 7 | 16.3 |
| | Combination | - | - |
| | No inclusions | 22 | 51.2 |
| Contours | Regular, clear | 35 | 81.4 |
| | Irregular, unclear | 8 | 18.6 |
| Accumulation of contrast | High | 27 | 62.8 |
| | Medium | 9 | 20.9 |
| | Low | 7 | 16.3 |


***Figure 3.*** *Magnetic resonance imaging fragments of Patient C., 64 years old. In the right eyeball, adjacent to the posterior membranes.*

The structure of the pathological formation was homogenous in 74.4% of cases. The heterogeneity of the structure of the tumors was revealed in 25.6% of cases, while in more than half of the patients, no additional inclusions were detected, and in the rest, the presence of areas of fat density and calcinites was determined.

During studies under intravenous bolus contrast with cyclolux and Gadovist, 62.8% showed active high accumulation of contrast in the tumor, indicating a developed vascular network in the tumor formation. In 20.9% of cases, a moderate accumulation of the contrast agent was observed, and in 16.3%, the contrast agent was insignificantly accumulated in the tumor tissue.

When analyzing the magnetic resonance image of the primary tumors of the orbit and eyeball, the following features were revealed, depending on the morphological version of the tumor.

Melanomas that were mostly found in the eyeball had a regular, clear contour (92.3%) and a uniform structure. In some studies, small retinal detachments were visualized. No changes were observed in the ocular motor muscles or orbital tissue.

Here is an example of a clinical study:

Patient C., a 64-year-old woman. She came to the clinic with complaints of a sharp deterioration in the right eye.

On the tomograms obtained after the magnetic resonance imaging (Figure 3) in the right eyeball, adjacent to the posterior membranes, in the vitreous body, on the meridian of 8:00-10:00, there are observed an irregular shape, heterogeneous structure, hyperintense (T1tse - MR data indicated the presence of melanin), an intensely contrasted volumetric neoplasm that allows limited diffusion, with the following dimensions: the maximal transverse diameter - 0.7 cm, the maximal transverse diameter on the short axis - 0.6 cm, craniocaudal measurement - 0.8 cm, the tumor extends to the optic papilla, does not extend to the retrobulbar space. Adjacent to the neoplasm, retinal detachment is observed.

A neoplasm of the irregular shape and heterogeneous structure is observed.

Of particular note is the hyperintense signal of neoplasm in the right eyeball in the precontrast T1tse mode, which indicates the presence of melanin or hemoglobin breakdown products. Post-contrast subtraction studies are crucial for differentiation. The patient was diagnosed with melanoma of the right eyeball.

Most of the cavernous hemangiomas were solitary - 94.5% of cases. The shape of the cavernous hemangioma was irregular in all cases, contours were not clear in 57.4%. The internal structure of cavernous hemangioma was mostly equally heterogeneous - 88.6%, inclusions were determined in 30.8% of neoplasms, and inclusions of a mixed nature were visualized in 12.7%.

Here is an example of a clinical study:

Patient D., 65 years old, was referred to an ophthalmologist with complaints of right-sided proptosis and double.

The patient underwent the magnetic resonance imaging procedures (Figure 4).

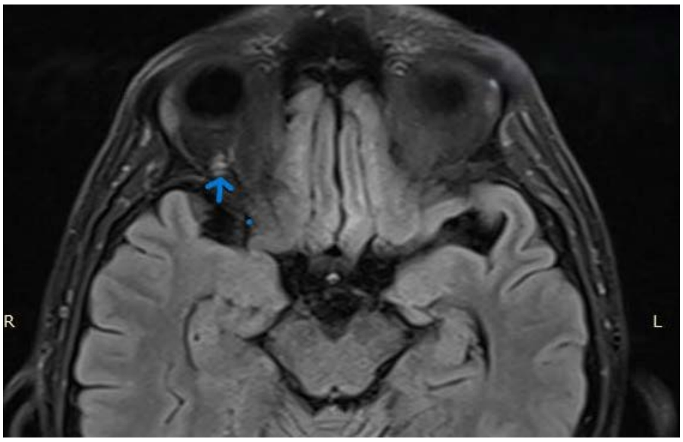


***Figure 4.*** *Magnetic resonance imaging fragment of Patient D., 65 years old.*

On the presented images in T2 tse and Flair modes, a small hyperintense, somewhat inhomogeneous tumor located in the right orbit is revealed.

On the obtained tomograms, in the right eye socket, cranially and laterally, a smooth, clearly contoured, inhomogeneous structure, an intensively contrasted volumetric tumor, measuring 0.5X0.9X0.5 cm, is shown, which does not cause pressure on the surrounding anatomical structures.

To make a final decision in radiological diagnostics, postcontrast imaging and its interpretation are of crucial importance. Figure 5 illustrates an image obtained using postcontrast T1 tse and subtraction modes.

The above neoplasm displays a homogeneous and intense inclusion of the contrast – by MR semiotics, it corresponds to cavernous hemangioma. The patient's final diagnosis is cavernous hemangioma.

For lacrimal gland adenoma, the characteristic localization of the tumor is observed - in the upper outer parts of the orbit, which corresponds to the localization of the lacrimal gland.

The shape of the tumor was irregular, with unclear contours in 88.5% of cases. In 75.4% of cases, the heterogeneity of

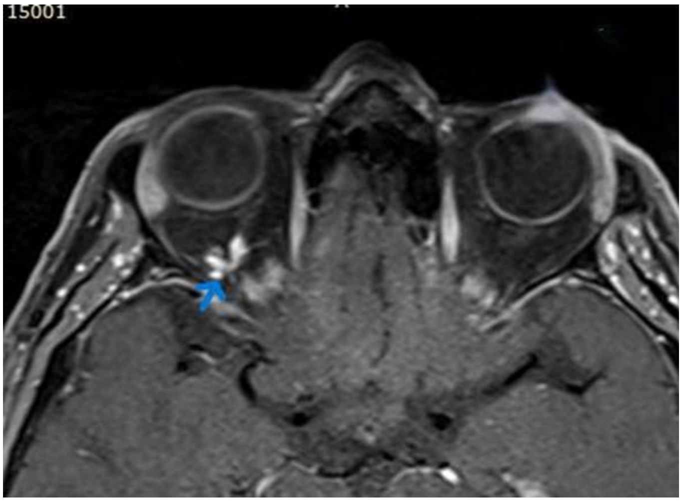


***Figure 5.*** *Postcontrast magnetic resonance imaging fragments of Patient D., 65 years old.*

the structure was revealed due to the large number of cystic structures.

Here is an example of a clinical study:

Patient V., a 60-year-old man, came to the clinic with complaints of worsening vision, pressure, and compression in the right eye.

Ophthalmological examination revealed restriction of movement of the eyeball laterally and narrowing of the palpebral fissure above and to the right. Visual acuity on the affected side is 0.6, and on the healthy side - 1.0. Fundus has signs of optic disc congestion. The boundaries of the visual fields are not changed.

The patient underwent the magnetic resonance imaging procedures.

On the obtained tomograms, the right projection area of the lacrimal gland shows a homogeneous and well-contrasted volumetric growth, which is inhomogeneous in the T2 mode, does not cause true diffusion restriction, and does not invade the surrounding structures. MRI of perineural tumor growth (through the ophthalmic division of the trigeminal nerve -- V1). No signs were detected, which is of crucial importance in determining the treatment and future outcome. Adenoid cystic carcinoma of the lacrimal gland was morphologically verified.

In orbital lymphomas, the oval shape of the neoplasm prevailed, with clear contours in 83% of cases. The tumor was most often localized in the posterolateral parts of the orbit.

The heterogeneity of the structure (84%) is characteristic. Densitometric inclusions of low and high density were found in an equal percentage ratio.

Contrast agent accumulation by tumor tissue was high in 60% of cases, and moderate contrast accumulation was observed in the remaining 40%. A change in the surrounding tissues was detected in 38% of cases - a decrease in their densitometric density and a change in structure were observed.

Here is an example of a clinical study:

Patient O., a 56-year-old woman. She came to the clinic with complaints of left-sided exophthalmos and a sharp deterioration in vision.

On the tomograms obtained after the magnetic resonance imaging (Figure 6) in the apex of the left eyeball, around

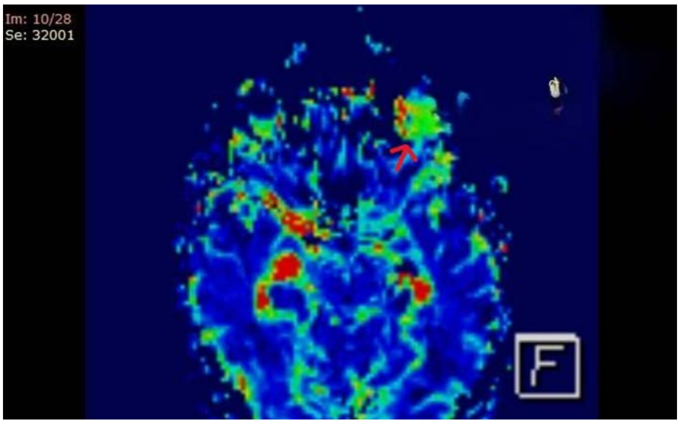


***Figure 6.** Magnetic resonance imaging fragments of Patient O., 56 years old.*

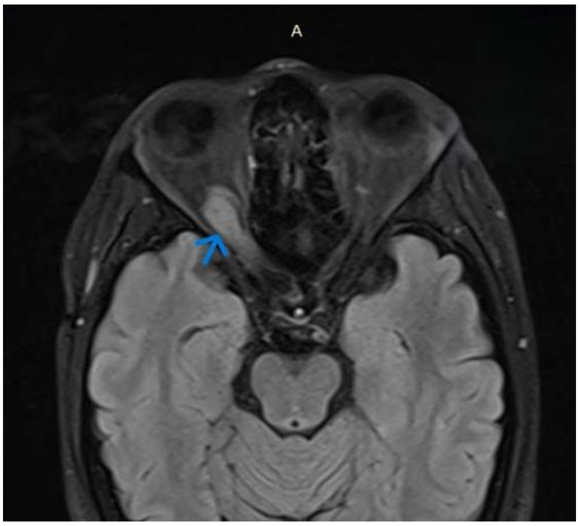


***Figure 7.** Magnetic resonance imaging fragments of Patient U., 25 years old.*

the optic nerve, cranially, laterally, and caudally, there is an irregularly shaped, intensely contrasted mass with unclear contours, with the following dimensions: anterior-posterior 1.2 cm, transversal - 0, 9 cm, craniocaudal measurement - 0.8 cm, giving limited diffusion (indicating cellular proliferation).

MR perfusion refers to increased perfusion. A small defect of the lateral wall is revealed in the area of the apex, the said mass extends slightly into the middle fossa. The optic nerve is not differentiated distal to the said mass. The eye-moving muscles are thickened and infiltrated in the apex of the eyeball, especially the superior rectus muscle. The left eyeball is deformed, the vitreous body has a non-homogeneous structure, and MR retinal detachments are observed with a centrally fibrous stroma - intraorbital lymphoma is suspected by MR semiotics. The patient was finally diagnosed with lymphoma.

The majority of retinoblastomas were characterized by an irregular shape, with unclear contours in 75% of cases. The tumor was most often localized in the eyeball and lower quadrant. In the case of retinoblastoma, structural heterogeneity prevailed (87%).

Here is an example of a clinical study:

Patient R., 1 year old, with left-sided proptosis. There is no trauma of any kind in the anamnesis. A magnetic resonance imaging procedure was performed.

On the obtained tomograms, T2 and post-contrast slices visualized a strongly inhomogeneous structure, partially patchy (hypointense in T2 mode), and inhomogeneously contrasted intraorbital volumetric neoplasm, which extends dorsally along the optic nerve. The intracranial spread of the tumor near the optic chiasm is also observed. The tumor shows increased perfusion and pathological restriction of diffusion. Considering the patient's age and magnetic resonance data, retinoblastoma is an alternative diagnosis, which was confirmed by the morphological verification of the drug.

In the case of menangiomas, the irregular shape of the tumor prevailed, with clear contours in 87% of cases. Meningiomas are characterized by heterogeneity of structure (89%).

Here is an example of a clinical study:

Patient U., a 25-year-old woman, came to the clinic with complaints of deterioration of vision in the right eye.

On the obtained tomograms (Figure 7) in the right eye socket, dorsally and in the area of the apex of the eye socket, adjacent to the optic nerve - laterally and craniocaudally, there is an irregular, clearly contoured, inhomogeneous structure, intensively contrasting volumetric neoplasm the following with dimensions: anterior-posterior - 2.1 cm, transverse - 1.1 cm, length - 1.3 cm, which does not extend intracranially. The right optic nerve is sharply pinched and intact approximately 1 cm dorsal to the eyeball.

In the postcontrast perfusion mode, the tumor showed no significant increase in perfusion parameters, as well as pathological restriction of diffusion - indicating a highly differentiated cellular matrix of the tumor.

Considering the homogeneity of the contrast and the close connection with the optic nerve, by MR to semiotics, the presence of a neoplasm of the optic nerve is probable - a meningioma of the right optic nerve sheath was morphologically verified.

## Discussion.

As a result of the analysis of the obtained data, the sensitivity of MRI in the diagnosis of primary tumors of the orbit and eyeball was 99%, and specificity was 96.4%.

From the data, it follows that according to magnetic resonance imaging data, eye movement muscle infiltration was suspected in 11.6% of cases, since a clear border between the tumor and any muscle group was not defined, while there was a corresponding muscle size increase [17,18].

In 4.66% of cases, it was assumed that optic nerve infiltration occurred based on the close location of the tumor and the impossibility of its clear visualization.

Changes in the retrobulbar tissue and its infiltration were detected in 23.3% of cases.

In 18.61% of cases, the destruction of the orbital bone wall was observed, while the destruction of the medial orbital wall was observed in 2.33% of cases, lateral - in 9.3%, and the upper one - in 6.98%. When evaluating the condition of the orbital bone walls, it was noted that destructive changes were more often detected in the lateral and cranial parts of the orbit.

***Table 3.*** *Comparative characteristics of ultrasound, computed tomography, and magnetic resonance imaging in the diagnosis of primary tumors of the eyeball and orbit.*

| Signs | | Ultrasound examination (n=30) | | CT (n – 38) | | MRI (n – 43) | |
|---|---|---|---|---|---|---|---|
| | | Abs. | % | Abs. | % | Abs. | % |
| Infiltration of eye movement muscles | Yes | 6 | 20,0 | 5 | 13,2 | 5 | 11,6 |
| | No | 24 | 80,0 | 33 | 86,8 | 38 | 88,4 |
| Dimensions of eye movement muscles | Remained unchanged | 23 | 76,7 | 31 | 81,6 | 35 | 81,4 |
| | Reduced | - | - | - | - | - | - |
| | Enlarged | 8 | 18,6 | 7 | 18,4 | 8 | 18,6 |
| Retrobulbar tissue changes | Yes | 8 | 26,7 | 10 | 26,3 | 10 | 23,3 |
| | No | 22 | 73,3 | 28 | 73,7 | 33 | 76,7 |
| Optic nerve infiltration | Yes | 3 | 10,5 | 2 | 5,3 | 2 | 4,66 |
| | No | 27 | 89,5 | 36 | 94,7 | 41 | 95.34 |
| Destruction of the bone wall of the orbit | Medial | - | - | 1 | 2.9 | 1 | 2,33 |
| | Lateral | 3 | 10,5 | 3 | 7,9 | 4 | 9,30 |
| | Upper | 2 | 6,7 | 3 | 7.9 | 3 | 6,98 |
| | Lower | 2 | 6,7 | - | - | - | - |

***Table 4.*** *The effectiveness of radiological research methods in assessing the spread of primary neoplasms of the eyeball and orbit.*

| Signs | Methods | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ultrasonography | | | CT | | | MRI | | |
| | Sensitivity, % | Specificity, % | Accuracy, % | Sensitivity, % | Specificity, % | Accuracy, % | Sensitivity, % | Specificity, % | Accuracy, % |
| Infiltration of muscles | 85,0 | 75,0 | 88,0 | 85,0 | 90,0 | 90,0 | 96,2 | 95,7 | 97,3 |
| Optic nerve infiltration | 83,0 | 71,0 | 84,0 | 78,0 | 83,0 | 83,0 | 95,4 | 96,1 | 97,2 |
| Infiltration of retrobulbar tissue | 85,0 | 72,0 | 87,0 | 88,0 | 89,0 | 90,0 | 96,8 | 95,3 | 98,0 |
| Destruction of the bone wall of the orbit | 75,0 | 67,0 | 72,0 | 95,0 | 97,4 | 94,1 | 99,0 | 96,4 | 98,1 |

The results obtained by magnetic resonance imaging were fully confirmed by the morphological study of tissues obtained during surgery.

The capabilities of traditional instrumental research methods are limited by their resolution capability. Diagnostic errors are also common. Therefore, the interest caused by the development and implementation of new additional research methods for timely diagnosis of orbital diseases is understandable [19].

Given that one of the goals of our study was to assess the capabilities of modern radiological methods of research in imaging the tumor formations of the eyeball and orbital space and in assessing the degree of their spread, we conducted a comparative analysis of the results obtained in these studies. Table 3 presents the results of the comparative evaluation of magnetic resonance imaging, ophthalmo-sonography and computed tomography data for primary tumors of the eyeball and orbit.

Destruction of the orbital bone walls during ultrasound examination was observed in 18.7% of cases, while destruction of the lateral orbital bone wall was visualized in 10.5% of cases, the upper one - in 6.7% of cases, and destruction of the lower wall was observed in 6.7% of cases.

During computed tomography, destruction of the orbital bone walls was observed in 23.9% of cases, while destruction of the lateral and upper orbital walls was observed in 7.9% of cases each, and no destruction of the lower orbital was noted.

During magnetic resonance imaging, destruction of the bony walls of the orbit was visualized in 18.6% of cases, while destruction of the lateral and superior walls of the orbit was observed in 9.30% and 6.98% of cases, respectively, and no destruction of the inferior orbital wall was observed. During surgery, destructive changes in the superior orbital wall were confirmed in 6.98% of cases, and ultrasound examination did not reveal destructive changes in this case, which can be explained by the features of the location of the tumor.

When analyzing the effectiveness of radiological examination methods in assessing the prevalence of primary neoplasms of the eyeball and orbit, we evaluated parameters such as sensitivity, specificity, and accuracy (Table 4).

When assessing the spread of the primary tumor to the soft tissue structures of the orbit, CT results were lower than those obtained with MRI. This is explained by the relatively low sensitivity of CT in assessing soft tissue structures of the orbit, which is not inconsistent with written records [20,21].

Thus, according to our data, all used radiological methods (ultrasound, computed tomography, and magnetic resonance imaging) are important both in the diagnosis of primary tumors of the eyeball and orbit, as well as in the planning of surgical treatment, but magnetic resonance imaging leads in sensitivity, specificity, and accuracy.

Currently, the most important methods for diagnosing orbital tumors are computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound ramination.

Of all tissue imaging methods, the magnetic resonance imaging procedure provides the most complete pathoanatomical picture, and also allows for conducting non-invasive angiographic examination and obtaining diffusion, perfusion, and spectroscopy images.

MRI, unlike CT, can diagnose small tumor foci, which allows us to differentiate neoplasms in time and plan further treatment.

MRI is more sensitive in terms of detecting small tumors of both soft tissues and bone structures of the orbit and eyeball than CT and ultrasound examination, so the MRI procedure is definitely on the front line in the differential diagnosis of orbital neoplasms.

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**„orbitis neoplazmebis kvleva magnitur-rezonansuli tomografiis meTodiT**

mxedvelobis organos warmonaqmnebs axasiaTebT mniSvnelovani polimorfizmi, rac TvalbudeSi arsebuli struqturebis histologiuri mravalferovnebiTaa ganpirobebuli. kvlevis mizani iyo Tvalis kaklisa da Tvalbudis simsivnuri warmonaqmnebis mqone pacientebSi magnitur-rezonansuli tomografiis diagnostikuri mniSvnelobis dadgena da MRI meTodis upiratesobis Cveneba kvlevis sxva instrumentuli meTodebTan SedarebiT.

naSromSi warmodgenilia orbitis paTologiuri procesebis mqone 67 pacientis kvlevis Sedegebi. pacientebis asaki meryeobda ramdenime Tvidan 81 wlamde. aqedan 23 (34,3 %) mamakaci da 44 (65,7%) qali iyo. magnitur-rezonansuli tomografia sruldeboda Siemens firmis aparatze MAGNETOM Vida 3T, sam proeqciaSi.

orbitisa da Tvalis kaklis pirveladi simsivneebis MRI semiotikis analizis Sedegad gamovlinda maTi saerTo niSnebi: warmonaqmnebis ovaluri formis upiratesoba, aseve umetesad simsivneebis zedapiri gluvi iyo, paTologiuri warmonaqmnis struqtura ZiriTadad iyo trTgvarovani. amasTan, pacientebis naxevarze met SemTxvevaSi damatebiTi CanarTebi ar gamovlenila, danarCenSi ki ganisazRvra dabali densitometriuli simkvrivis CanarTebi (5-dan 16 HU HU-mde) da erTeul SemTxvevebSi Zvliswarmoqmnis paTologiuri ubnebis gamo

dafiqsirda maRali densitometriuli simkvrivis (200-dan 400 HU-mde) CanarTebi.

cikloluqsiT da gadovistiT intravenuri bolusuri kontrastirebis pirobebSi kvlevebis dros 62,8%-Si gamovlinda kontrastis aqtiuri maRali dagroveba warmonaqmnSi, rac miuTiTebs ganviTarebul sisxlZarRvTa qselze simsivnur warmonaqmnSi.

qsovilebis vizualizaciis yvela meTodidan, magnitur-rezonansuli tomografia iZleva paToanatomiurTan yvelaze axlo suraTs da aseve saSualebas gvaZlevs CavataroT arainvaziuri angiografiuli gamokvleva, miviRoT difuziis, perfuziis da speqtroskopiis gamosaxulebebi.

**Sumarry**

**Study of orbital neoplasms by magnetic resonance imaging procedure**

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**Abstract.** The neoplasms of the organ of vision are characterized by significant polymorphism, which is due to the histological diversity of the structures in the eye socket. Almost all types of neoplasms described in humans are found in the orbit. The study aimed to determine the diagnostic value of magnetic resonance imaging in patients with tumors in the eyeball and the eye socket, as well as to determine the superiority of the MRI procedure compared to other instrumental methods of the research.

The paper presents the results of the study of 67 patients with pathological processes of the orbit, whose ages ranged from a few months to 81 years. Of them, 23 (34.3%) were men and 44 (65.7%) were women. Magnetic resonance imaging was performed on a Siemens MAGNETOM Vida 3T device in three projections. As a result of the analysis of MRI semiotics of primary tumors of the orbit and eyeball, their common features were revealed: the predominance of oval-shaped tumors. Also, in most cases, the contours of the tumors were regular and clear. The structure of the pathological formation was homogenous. The heterogeneity of the structure of the tumors was revealed in 25.6% of cases, while in more than half of the patients, no additional inclusions were detected, and in the rest, the presence of areas of fat density and calcinates was determined.

During studies under intravenous bolus contrast with cyclolux and Gadovist, 62.8% showed active high accumulation of contrast in the tumor, indicating a developed vascular network in the tumor formation.

Of all tissue imaging methods, the magnetic resonance imaging procedure provides the most complete pathoanatomical picture and allows for conducting non-invasive angiographic examination and obtaining diffusion, perfusion, and spectroscopy images.

***Key words:*** sagittal and axial slices, orbital neoplasms, intravenous bolus contrast, melanoma, cavernous hemangioma, adenoma of the lacrimal gland, lymphoma, retinoblastoma, menangioma, perfusion.

**Исследование новообразований орбиты методом магнитно-резонансной томографии**

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Для образований органа зрения характерен значительный полиморфизм, что обусловлено гистологическим разнообразием структур глазницы. Цель исследования - определить диагностическую ценность магнитно-резонансной томографии у больных с опухолями глазного яблока и орбиты и показать превосходство метода МРТ по сравнению с другими инструментальными методами исследования.

В работе представлены результаты исследования 67 пациентов с патологическими процессами орбиты. Возраст пациентов варьировался от нескольких месяцев до 81 года. Из них 23 (34,3%) были мужчинами и 44 (65,7%) – женщинами. Магнитно-резонансную томографию проводили на аппарате Siemens MAGNETOM Vida 3T в трех проекциях.

В результате анализа МРТ-семиотики первичных опухолей орбиты и глазного яблока выявлены их общие черты: преобладание овальной формы образований, а также поверхность опухолей преимущественно гладкая, а структура патологических образований однородная. Однако у более чем половины больных дополнительных включений не обнаружено, а у остальных определяются включения низкой денситометрической плотности (от 5 до 16 HU), а в ряде случаев за счет патологических участков костеобразования включения высокой денситометрической плотности (от 200 до 400 HU).

При исследований под внутривенным болюсным контрастированием циклолюксом и Гадовистом у 62,8% выявлено активное высокое накопление контраста в образовании, что свидетельствует о развитой сосудистой сети в опухолевом образовании.

Из всех методов визуализации тканей магнитно-резонансная томография обеспечивает наиболее близкое к патологоанатомическому изображение, а также позволяет проводить неинвазивное ангиографическое исследование, получать диффузионные, перфузионные и спектроскопические изображения.