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MRI-based morphological analysis and growth patterns of pituitary macroadenomas with different hormonal activity

Turli gormonal faollikka ega gipofiz makroadenomalarining MRT asosidagi morfologik tahlili va o'sish xususiyatlari

Морфологический анализ и особенности роста макроадеом гипофиза с различной гормональной активностью на основе МРТ

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Abstract. Relevance. Pituitary macroadenomas are clinically significant mass lesions of the sellar and parasellar region. Their clinical course is determined not only by tumor size but also by hormonal activity, growth direction, cavernous sinus invasion, suprasellar extension, and anatomical relationship with the optic chiasm. Magnetic resonance imaging is the main instrumental diagnostic method for evaluating the morphological structure, topographic-anatomical characteristics, and extension of pituitary macroadenomas into adjacent structures. Materials and methods. The study proposes MRI-based morphological criteria for evaluating pituitary macroadenomas. The analyzed parameters included tumor size, suprasellar and parasellar extension, cavernous sinus invasion, Knosp grade, optic chiasm compression, pituitary stalk deviation, cystic degeneration, necrotic changes, and hemorrhagic components. Results. Functioning and non-functioning pituitary macroadenomas may differ in growth direction and degree of invasiveness. In particular, prolactinomas and somatotropinomas may demonstrate more pronounced lateral invasion into the cavernous sinus, whereas non-functioning macroadenomas more often present with suprasellar extension and optic chiasm compression. Conclusion. MRI-based morphological analysis is important for assessing the biological behavior of pituitary macroadenomas, estimating surgical risk, and individualizing treatment strategy.

Keywords: pituitary macroadenoma; MRI; hormonal activity; prolactinoma; somatotropinoma; cavernous sinus; Knosp classification; suprasellar growth; optic chiasm

O'ZBEKCHA

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Annotatsiya. Dolzarblik. Gipofiz makroadenomalari sellar-parasellyar sohaning eng muhim hajmli hosilalari qatoriga kiradi. Ularning klinik kechishi nafaqat o'lchamiga, balki gormonal faolligi, o'sish yo'nalishi, kavernoziy sinusa invaziyasi, suprasellyar kengayishi va optik xiazma bilan munosabatiga ham bog'liq. Magnit-rezonans tomografiya gipofiz makroadenomalari aniqlash, ularning topografik-anatomik tarqalishini baholash va jarrohlik taktikasini rejalashtirishda asosiy diagnostik usul hisoblanadi. Material va usullar. Maqolada gipofiz makroadenomalari baholash uchun MRT-morfologik tahlil algoritmi ishlab chiqildi. Baholash mezonlari sifatida o'sma o'lchami, hajmi, suprasellyar va parasellyar kengayishi, Knosp darajasi, optik xiazma kompressiyasi, gipofiz oyoqchasi deviatitsiyasi, nekroz, kista, gemorragik o'zgarishlar va sfenoidal sinus bilan munosabat tahlil qilindi. Natijalar. Gormonal faol va nafaol makroadenomalarda o'sish yo'nalishi va invazivlik darajasi bo'yicha farqlanishi mumkin. Prolaktinomalarda va somatotropinomalarda ayrim holatlarda

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kavernoz sinusga lateral invaziya, nafaol makroadenomalar esa ko'proq suprasellyar kengayish va optik xiazma kompressiyasi bilan namoyon bo'ladi. Xulosa. MRT asosidagi morfologik tahlil gipofiz makroadenomalarning biologik xatti-harakati, operatsion xavfi va davolash taktikasini individual belgilashda muhim ahamiyatga ega.

Kalit so'zlar: gipofiz makroadenomasi; PitNET; magnit-rezonans tomografiya; gormonal faollik; prolaktinoma; somatotropinoma; kavernoz sinus; Knosp tasnifi; suprasellyar o'sish; optik xiazma

РУССКИЙ

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Аннотация. Актуальность. Макroadеномы гипофиза относятся к числу наиболее значимых объемных образований sellарно-параселлярной области. Их клиническое течение определяется не только размерами опухоли, но и гормональной активностью, направлением роста, степенью инвазии кавернозного синуса, супраселлярным распространением и взаимоотношением с хиазмой зрительных нервов. Магнитно-резонансная томография является основным методом диагностики, топографо-анатомической оценки и планирования хирургической тактики при макroadеномах гипофиза. Материал и методы. В статье предложен алгоритм МРТ-морфологической оценки макroadеном гипофиза. В качестве критериев анализа рассматривались размеры и объем опухоли, супраселлярное и параселлярное распространение, степень по Knosp, компрессия зрительной хиазмы, девиация ножки гипофиза, наличие некроза, кистозной дегенерации, геморрагических изменений и взаимоотношение со сфеноидальным синусом. Результаты. Функционирующие и нефункционирующие макroadеномы гипофиза могут различаться по направлению роста и степени инвазивности. Пролактиномы и соматотропиномы в ряде случаев характеризуются латеральной инвазией в кавернозный синус, тогда как нефункционирующие макroadеномы чаще проявляются супраселлярным ростом и компрессией зрительной хиазмы. Заключение. МРТ-морфологический анализ имеет важное значение для оценки биологического поведения макroadеном гипофиза, определения операционного риска и индивидуализации лечебной тактики.

Ключевые слова: макroadенома гипофиза; PitNET; магнитно-резонансная томография; гормональная активность; пролактинома; соматотропинома; кавернозный синус; классификация Knosp; супраселлярный рост; зрительная хиазма

1. KIRISH

Introduction

Gipofiz makroadenomalari sellar va parasellyar sohaning eng muhim hajmli o'smalari qatoriga kiradi. Ular adenogipofiz hujayralaridan rivojlanib, diametri 10 mm va undan ortiq bo'lgan holatlarda makroadenoma sifatida baholanadi. Zamonaviy neyroendokrinologiyada gipofiz adenomalarning faqat anatomik hajmini emas, balki ularning gormonal faolligi, biologik xatti-harakati, invazivlik darajasi va qo'shni neyrovaskulyar tuzilmalar bilan munosabatini ham kompleks tahlil qilish muhim hisoblanadi [1, 2, 3]. So'nggi yillarda gipofiz o'smalariga nisbatan "pituitary neuroendocrine tumor" - PitNET atamasi ham keng qo'llanilmoqda. Bu atama o'smaning neyroendokrin kelib chiqishini, immunogistikimyoviy subtiplarini va ayrim hollarda invaziv o'sish ehtimolini yanada aniqroq ifodalashga xizmat qiladi [3, 6, 10]. Shunga qaramay, amaliy klinikada "gipofiz adenomasi" va "gipofiz makroadenomasi" atamaları huz keng qo'llaniladi. Gipofiz makroadenomalari klinik jihatdan ikki asosiy guruhga bo'linadi: gormonal faol va gormonal nafaol makroadenomalari. Gormonal faol makroadenomalarga prolaktinoma, somatotropinoma, kortikotropinoma, tireotropinoma va plurihormonal o'smalar kiradi. Bu o'smalar tegishli gormonlarning ortiqcha sekretsiyasi natijasida aniq endokrin sindromlar bilan namoyon bo'ladi. Masalan, prolaktinomalar giperprolaktinemiya, reproduktiv disfunktsiya va gipogonadizm bilan; somatotropinomalar akromegaliya yoki gigantizm bilan; kortikotropinomalar esa giperkortitsizm belgilari bilan kechadi [5, 11, 16].

Gormonal nafaol makroadenomalari esa klinik jihatdan aniq gipersekretor sindrom bermaydi. Ular ko'pincha o'smaning hajmli ta'siri hisobiga aniqlanadi. Bunday bemorlarda bosh og'rig'i, ko'rish maydonining torayishi, optik xiazma kompressiyasi,

gipopituitarizm, gipofiz oyoqchasi kompressiyasi va ayrim hollarda kavernoz sinus ichidagi bosh miya nervlari zararlanishi kuzatiladi. Shu sababli nafaol makroadenomalari ko'pincha kech bosqichda, o'sma suprasellyar yoki parasellyar sohalarga keng tarqalgandan keyin tashxislanadi [4, 7, 14]. Magnit-rezonans tomografiya gipofiz makroadenomalari aniqlash va baholashda asosiy diagnostik usul hisoblanadi. MRT yordamida o'smaning hajmi, shakli, ichki tuzilishi, kontrastlanish xususiyati, suprasellyar va parasellyar kengayishi, optik xiazma bilan munosabati, kavernoz sinusga invaziyasi, sfenoidal sinusga tarqalishi va ichki uyqu arteriyasi bilan topografik aloqasi aniqlanadi. Ayniqsa transsfenoidal jarrohlik rejalashtirilayotgan bemorlarda MRT xulosasi operatsion taktika uchun hal qiluvchi ahamiyatga ega [8, 9, 25]. Gipofiz makroadenomalarning o'sish yo'nalishi ularning klinik ko'rinishiga bevosita ta'sir qiladi. Yuqoriga, ya'ni suprasellyar yo'nalishda o'suvchi o'smalar optik xiazmani bosib, bitemporal gemianopsiya va ko'rish o'tkirligining pasayishiga olib keladi. Yon tomonga, ya'ni parasellyar yo'nalishda o'suvchi o'smalar kavernoz sinusga kirib borishi, III, IV, V va VI bosh miya nervlariga ta'sir qilishi, diplopiya, ptoz, yuz sohasida sezgi buzilishi va oftalmoplegiya bilan namoyon bo'lishi mumkin. Pastga, sfenoidal sinus tomonga o'suvchi makroadenomalari esa sellar tubining yuqalashishi, suyak remodelanishi va jarrohlik kirish yo'lining o'zgarishiga sabab bo'ladi.

Kavernoz sinus invaziyasini baholashda Knosp tasnifi muhim ahamiyatga ega. Ushbu tasnif ichki uyqu arteriyasi atrofidagi o'sma tarqalishini MRT asosida baholashga imkon beradi. Knosp 0–2 darajalarida o'smaning radikal rezeksiya qilinish ehtimoli nisbatan yuqori bo'lsa, Knosp 3–4 darajalarida kavernoz sinus ichida qoldiq o'sma saqlanib qolish xavfi ortadi [10, 13, 23].

2. MATERIAL VA USULLAR

Materials and methods

Tadqiqot klinik-radiologik tahlilga asoslangan retrospektiv kuzatuv modeli sifatida ishlab chiqildi. Tadqiqot obyekti sifatida gipofiz makroadenomasi tashxisi qo'yilgan bemorlarning klinik, endokrinologik va MRT ma'lumotlari tahlil qilindi. Maqola modeli uchun bemorlar gormonal faollik turiga ko'ra guruhlariga ajratildi: prolaktinoma, somatotropinoma, kortikotropinoma, tireotropinoma va gormonal nafaol makroadenoma. Tadqiqotga kiritish mezonlari quyidagilardan iborat bo'ldi: gipofiz sohasida diametri 10 mm va undan katta bo'lgan o'sma aniqlanishi; kontrastli MRT tekshiruvi mavjudligi; bemorda asosiy gipofizar gormonlar bo'yicha laborator tekshiruv o'tkazilganligi; klinik-nevrologik va oftalmologik

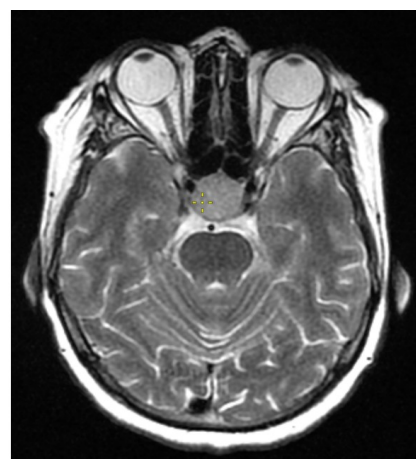
tekshiruv ma'lumotlarining mavjudligi; bemorning davolashgacha bo'lgan birlamchi MRT tasvirlari tahlil uchun yaroqli bo'lishi. Tadqiqotdan chiqarish mezonlari sifatida quyidagilar belgilandi: avval gipofiz sohasida jarrohlik amaliyoti o'tkazilgan bemorlar; radioterapiyadan keyingi holatlar; sellar-parasellyar sohaning boshqa o'smalari, jumladan meningioma, kraniofaringioma, metastaz, germinoma yoki Rathke cho'ntagasi kistasi; MRT tasvirlarining yetarli sifatda bo'lmashligi; gormonal tekshiruvlarning to'liq emasligi. MRT tekshiruvi 1,5 T yoki 3,0 T magnit-rezonans tomograf apparatlarida bajarilishi mumkin. Standart protokol T1-rejimli sagittal va koronar kesimlar, T2-rejimli tasvirlar, kontrastdan keyingi T1-rejimli koronar va sagittal yupqa kesimli tasvirlar va zarur hollarda dinamik kontrastli tekshiruv ketma-ketliklarini o'z ichiga oldi (Rasm-1).



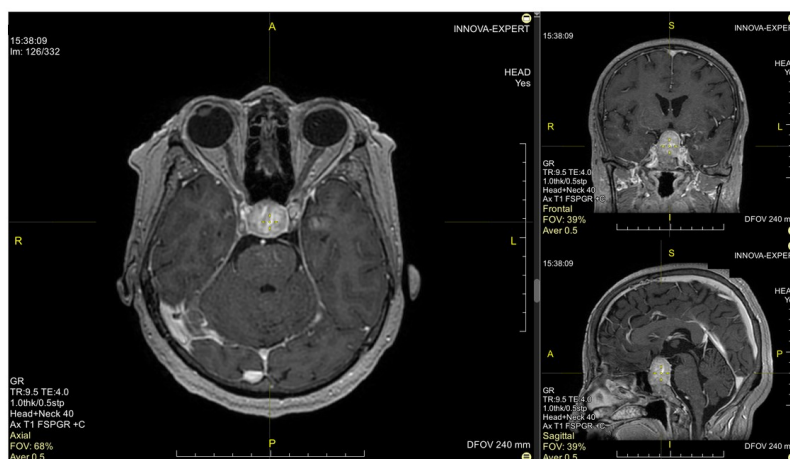
MRT koronar T1 rejimi



MRT sagittal T1 rejimi



MRT aksial T2 rejimi

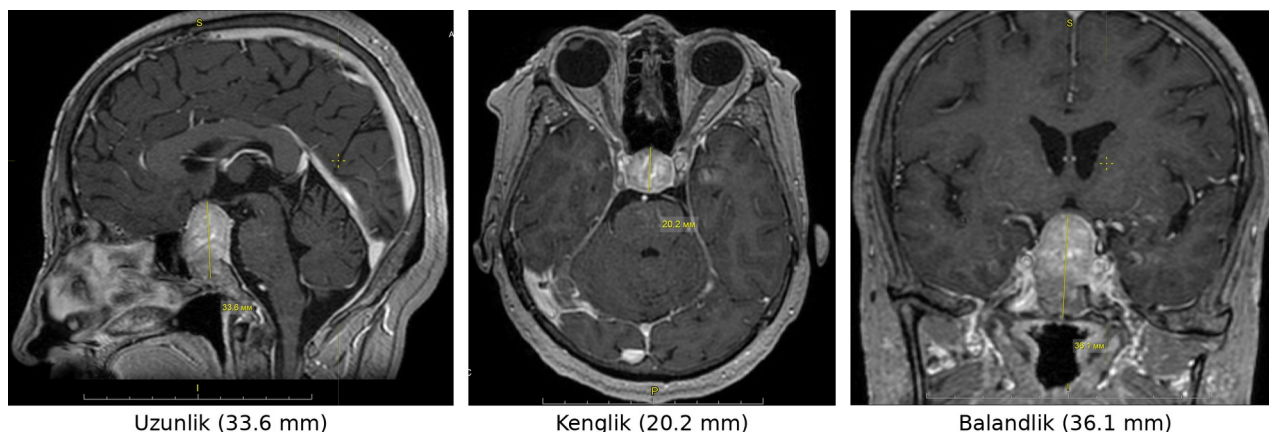


Kontrastli MRT tekshiruvining aksial, koronar va sagittal kesimlari

1-rasm. Standart protokol asosidagi MRT tekshiruvi / **Fig. 1.** MRI examination according to the standard protocol

MRT-morfologik tahlilda quyidagi belgilar baholandi: o'smaning maksimal kraniokaudal, transversal va anteroposterior o'lchami; taxminiy hajmi; sellar soha chegaralaridan tashqariga chiqishi; suprasellyar kengayish; optik xiazma kompressiyasi; parasellyar kengayish; kavernozi sinus invazyasi; Knosp darajasi; gipofiz oyoqchasi deviasiyasi; sfenoidal sinusga pastki o'sish; ichki uyqu arteriyasi bilan munosabat; o'sma ichida kistik degeneratsiya, nekroz yoki gemorragik komponent mavjudligi.

O'sma hajmini baholashda ellipsoid formula qo'llanilishi mumkin: «**Hajm = uzunlik × kenglik × balandlik × 0,52**»



2-rasm. Bemor A.S.ning gipofiz makroadenomasining hajmi (33.6x20.2x36.1x0.52=12741 mm³) / **Fig. 2.** Volume of the pituitary macroadenoma in patient A.S. (33.6x20.2x36.1x0.52=12741 mm³)

Bu usul makroadenomaning taxminiy hajmini baholash va keyingi nazorat MRT tekshiruvlarida o'sma regressiyasi yoki progressiyasini solishtirish uchun qulay hisoblanadi.

Gormonal faollik laborator tekshiruvlar asosida baholandi. Prolaktin, o'sish gormoni, IGF-1, AKTG, kortizol, TSH, erkin T4, LH, FSH va testosteron yoki estradiol ko'rsatkichlari tahlil qilindi. Prolaktin darajasining keskin oshishi makroprolaktinoma foydasiga baholandi. O'rtacha darajadagi prolaktin oshishi esa gipofiz oyoqchasi kompressiyasi bilan bog'liq "stalk effect" ehtimoli nuqtayi nazaridan ko'rib chiqildi. Ko'rish tizimi holatini baholash uchun oftalmologik tekshiruv natijalari, jumladan ko'rish o'tkirligi, perimetriya va ko'z tubi ma'lumotlari tahlil qilindi. Optik xiazma kompressiyasi MRTda xiazmaning yuqoriga siljishi, yassilanishi yoki to'g'ridan-to'g'ri bosilishi bilan baholandi. Kaverno sinus invaziyasi Knosp tasnifi asosida baholandi. Knosp 0–2 darajalari nisbatan cheklangan parasellyar kengayish sifatida, Knosp 3–4 darajalari esa invaziv o'sish ehtimoli yuqori bo'lgan holat sifatida talqin qilindi. Ayniqsa Knosp 4 darajasida ichki uyqu arteriyasining o'sma bilan to'liq o'ralishi yoki kaverno sinusning keng egallanishi jarrohlik xavfining yuqoriligini ko'rsatadi. Statistik tahlil uchun bemorlar gormonal faollik bo'yicha guruhlariga ajratildi. Miqdoriy ko'rsatkichlar o'rtacha qiymat va standart og'ish ko'rinishida, sifat ko'rsatkichlari esa son va foizlarda ifodalandi. Guruhlararo farqlarni baholashda χ^2 testi, Fisher mezoni, Student t-testi yoki Mann–Whitney U testi qo'llanilishi mumkin. Statistik ahamiyatlilik darajasi $p < 0,05$ sifatida qabul qilinadi.

3. NATIJALAR

Results

MRT-morfologik tahlil natijalari turli gormonal faollikka ega gipofiz makroadenomalarda o'sish yo'nalishi, invazivlik darajasi va qo'shni anatomik tuzilmalarga ta'sir qilish xususiyatlari farqlanishini ko'rsatdi. Gormonal nafaol makroadenomalarda ko'proq suprasellyar o'sish, optik xiazma kompressiyasi va yirik hajm bilan namoyon bo'ldi. Gormonal faol makroadenomalarda orasida esa prolaktinomalar va somatotropinomalarda parasellyar kengayish hamda kaverno sinus invaziyasi nisbatan ko'proq uchradi. Namuna sifatida tuzilgan klinik-radiologik modelda bemorlar gormonal faollik bo'yicha quyidagicha taqsimlandi.

2-jadval

Gormonal faollik bo'yicha MRT-morfologik belgilar / **Table 2.** MRI morphological features by hormonal activity

MRT belgisi	Nafaol adenoma	Prolaktinoma	Somatotropinoma	Kortikotropinoma
Suprasellyar kengayish	Ko'p uchraydi	O'rtacha	O'rtacha	O'rtacha
Optik xiazma kompressiyasi	Yuqori	O'rtacha	O'rtacha	Kam/o'rtacha
Kaverno sinus invaziyasi	O'rtacha	Yuqori	Yuqori	O'rtacha
Sfenoidal sinusga o'sish	Kam/o'rtacha	O'rtacha/yuqori	Kam/o'rtacha	Kam
Kistik-nekrotik o'zgarish	O'rtacha	O'rtacha	Kam/o'rtacha	O'rtacha
Gipofiz oyoqchasi deviasiyasi	Yuqori	O'rtacha	O'rtacha	O'rtacha

1-jadval

Gipofiz makroadenomalarning gormonal faollik bo'yicha taqsimlanishi / **Table 1.** Distribution of pituitary macroadenomas by hormonal activity

Makroadenoma turi	Bemorlar soni	Ulushi
Gormonal nafaol makroadenoma	28	38,9%
Prolaktinoma	18	25,0%
Somatotropinoma	14	19,4%
Kortikotropinoma	5	6,9%
Tireotropinoma	2	2,8%
Plurihormonal makroadenoma	5	6,9%
Jami	72	100%

Gormonal nafaol makroadenomalarda guruhida bemorlarning asosiy shikoyatlari bosh og'rig'i, ko'rish maydonining torayishi va umumiy holsizlikdan iborat bo'ldi. MRTda bu guruhdagi o'smalar ko'pincha yirik hajmga ega bo'lib, sellar diafragmadan yuqoriga o'sish va optik xiazmani bosish bilan tavsiflandi. Ko'rish xiazmasi kompressiyasi ushbu guruhda eng muhim radiologik va klinik belgi sifatida qayd etildi. Prolaktinoma guruhida o'smaning o'rtacha hajmi nisbatan katta bo'lib, ayrim holatlarda kaverno sinusga lateral invaziya kuzatildi. Bu guruhda o'sma ichida kistik degeneratsiya yoki gemorragik komponentlar ham uchradi. Makroprolaktinomalar, ayniqsa erkak bemorlarda, kech aniqlanishi va katta hajmga yetishi bilan ajralib turdi. Somatotropinoma guruhida bemorlarda akromegaliya belgilari - yuz skeleti va qo'l-oyoq distal qismlarining kattalashishi, yumshoq to'qimalar gipertrofiyasi, arterial gipertenziya, metabolik buzilishlar va bosh og'rig'i kuzatildi. MRTda bu o'smalar sellar-parasellyar joylashuvga ega bo'lib, ayrim hollarda kaverno sinus medial devori bilan yaqin aloqada bo'ldi. Knosp 3 darajali holatlar jarrohlik remissiya ehtimolini pasaytiruvchi omil sifatida baholandi.

Kortikotrop makroadenomalarda son jihatdan kam uchradi, biroq klinik jihatdan og'irroq kechishi bilan farq qildi. Giperkortitsizm, arterial gipertenziya, qand almashinuvi buzilishi va tana vaznining ortishi bu guruhdagi bemorlarda asosiy klinik belgilar bo'ldi. MRTda kortikotrop makroadenomalarda ayrim hollarda heterogen tuzilishga va parasellyar kengayishga ega bo'ldi.

O'sma hajmi va optik xiazma kompressiyasi o'rtaida bevosita bog'liqlik aniqlandi. Hajmi katta bo'lgan makroadenomalarda xiazma kompressiyasi, ko'rish yo'llari deformatsiyasi va suprasellyar kengayish ko'proq uchradi. Biroq kaverno sinus invaziyasi har doim ham o'smaning umumiy hajmiga bog'liq emasligi kuzatildi. Ayrim o'rtaida hajmdagi gormonal faol makroadenomal ham lateral yo'nalishda agressiv o'sish xususiyatini ko'rsatishi mumkin. Knosp tasnifi bo'yicha tahlilda nafaol makroadenomalarda Knosp 0–2 darajalari ko'proq uchradi, prolaktinoma va somatotropinoma guruhlarida esa Knosp 3–4 darajalari nisbatan yuqori bo'ldi. Bu holat gormonal faol makroadenomalarning ayrim turlarida kaverno sinusga invaziv o'sish ehtimoli yuqoriroq bo'lishi mumkinligini ko'rsatadi.

3-jadval

Knosp darajasi bo'yicha guruhlar taqsimoti / **Table 3.** Distribution of groups by Knosp grade

Knosp darajasi	Radiologik tavsif	Klinik ahamiyati
Knosp 0	O'sma ichki uyqu arteriyasining medial chizig'idan o'tmaydi	Radikal rezeksiya ehtimoli yuqori
Knosp 1	O'sma medial chiziqqa yetadi	Cheklangan parasellyar kengayish
Knosp 2	O'sma lateral chiziqqacha boradi	Kaverno sinusga yaqin joylashuv
Knosp 3	O'sma lateral chiziqdan o'tadi	Invaziya ehtimoli yuqori
Knosp 4	Ichki uyqu arteriyasi o'sma bilan o'raladi	Radikal rezeksiya qiyin, qoldiq o'sma xavfi yuqori

MRTda gipofiz oyoqchasining deviasiyasi nafaol makroadenomal va yirik prolaktinomalarda ko'proq kuzatildi. Bu holat gipofiz oyoqchasining mexanik bosilishi va ikkilamchi gormonal o'zgarishlar, xususan o'rtaida giperprolaktinemiya bilan bog'liq bo'lishi mumkin. Shuning uchun prolaktin darajasini talqin qilishda o'smaning hajmi va gipofiz oyoqchasi bilan munosabati alohida hisobga olinishi kerak. O'sma ichki tuzilishiga ko'ra bir jinsli va heterogen ko'rinishdagi makroadenomal ajratildi. Geterogen tuzilish kistik degeneratsiya, nekroz, gemorragik o'zgarishlar yoki eski qon quyilish o'choqlari bilan bog'liq bo'lishi mumkin. Gemorragik komponent aniqlangan bemorlarda gipofiz apopleksiyasi xavfi e'tiborga olinishi lozim. MRT asosidagi tahlil shuni ko'rsatdiki, gipofiz makroadenomalarning morfologik bahosi jarrohlik yondashuvini rejalashtirishda muhim o'rin tutadi. Suprasellyar o'sish optik apparat dekompressiyasi zarurligini, parasellyar invaziya esa kaverno sinus ichida qoldiq o'sma qolishi ehtimolini ko'rsatadi. Sfenoidal sinusga pastki kengayish va sellar tubining yuqqalashishi transsfenoidal kirish texnikasini tanlashda ahamiyatli hisoblanadi.

4. MUHOKAMA

Discussion

Olingan tahlil gipofiz makroadenomalarning gormonal faolligi ularning morfologik va topografik xususiyatlari bilan bog'liq bo'lishi mumkinligini ko'rsatadi. Gormonal nafaol makroadenomal ko'pincha uzoq vaqt davomida klinik belgisiz kechadi. Shuning uchun ular ko'pincha katta hajmga yetgandan keyin aniqlanadi. Bunday bemorlarda birlamchi klinik belgilar endokrin gipersekresiya bilan emas, balki mass-effekt bilan bog'liq bo'ladi. Optik xiazma kompressiyasi va ko'rish maydoni buzilishi nafaol makroadenomalarning eng muhim diagnostik belgilaridan biridir [23, 30, 31, 32]. Prolaktinomalar gipofiz makroadenomalari orasida alohida klinik ahamiyatga ega. Chunki ko'pchilik holatlarda ular birlamchi dori terapiyasiga, xususan dopamin agonistlariga sezgir bo'ladi. Biroq makroprolaktinomalar katta hajmga ega bo'lsa, kaverno sinus invaziyasi, sfenoidal sinusga

kengayish va ichki uyqu arteriyasi bilan yaqin munosabat aniqlanishi mumkin. Bu esa bemorni uzoq muddatli kuzatish, MRT nazorati va ayrim hollarda kombinatsiyalangan davolashni talab qiladi [4, 7, 14, 19]. Somatotropinomalarda o'smaning MRT-morfologik belgilarini aniqlash jarrohlik remissiya prognozi uchun muhimdir. Akromegaliyada operatsiyadan keyingi biokimyoviy remissiya ko'p jihatdan o'smaning hajmi, kaverno sinusga invaziyasi va rezeksiya radikalligiga bog'liq. Knosp 3–4 darajali somatotrop makroadenomalarda to'liq rezeksiya qilish qiyinlashadi, bu esa operatsiyadan keyingi medikamentoz davolash yoki radioterapiya ehtimolini oshiradi [2, 6, 18, 27].

Kortikotrop makroadenomal nisbatan kam uchrasa-da, klinik jihatdan murakkab hisoblanadi. Giperkortitsizm bemorning umumiy somatik holatiga salbiy ta'sir ko'rsatadi. Arterial gipertenziya, diabet, immunosupressiya, osteoporoz va tromboembolik asoratlari jarrohlik xavfini oshiradi. Shu sababli kortikotrop makroadenomal aniqlanganda MRT-morfologik tahlil bilan bir qatorda endokrin va metabolik holatni chuqur baholash zarur. Kaverno sinus invaziyasi gipofiz makroadenomalarning jarrohlik davolash natijalariga ta'sir qiluvchi asosiy omillardan biridir. Kaverno sinus ichida ichki uyqu arteriyasi, III, IV, V1, V2 va VI bosh miya nervlari joylashgani sababli bu sohaga invaziv o'sgan o'smalarni radikal olib tashlash doimo yuqori xavf bilan bog'liq. Shu bois Knosp 3–4 darajali holatlarda jarrohlikning maqsadi har doim ham maksimal radikal rezeksiya emas, balki xavfsiz dekompressiya va keyingi qo'shimcha davolash imkoniyatini yaratish bo'lishi mumkin [5, 11, 16, 32].

MRT xulosasida o'smaning faqat o'lchamini ko'rsatish yetarli emas. Radiologik bayonnomada o'smaning aniq o'sish yo'nalishi, kaverno sinusga kirib borish darajasi, optik xiazma bilan munosabati, gipofiz oyoqchasi deviasiyasi, normal gipofiz to'qimasining joylashuvi va sfenoidal sinus anatomiyasi ko'rsatilishi lozim. Bu ma'lumotlar neyroxirurgik kirish yo'lini tanlash, operatsion xavfni baholash va operatsiyadan keyingi qoldiq o'sma ehtimolini oldindan aniqlash imkonini beradi. Gipofiz makroadenomalarda gormonal faollik va MRT belgilarining integratsiyalangan tahlili differensial diagnostika uchun ham muhimdir. Masalan, yirik sellar o'sma fonida prolaktin darajasining juda yuqori bo'lishi makroprolaktinoma ehtimolini oshiradi. Biroq prolaktinning o'rtaida oshishi nafaol makroadenoma tomonidan gipofiz oyoqchasining bosilishi natijasida ham yuzaga kelishi mumkin. Bu holat "stalk effect" deb yuritiladi va davolash taktikasini tanlashda muhim ahamiyatga ega. O'smaning ichki tuzilishi ham klinik jihatdan ahamiyatlidir. Kistik degeneratsiya, nekroz yoki gemorragik komponent o'smaning uzoq davom etganligi, qon aylanish buzilishi yoki gipofiz apopleksiyasi xavfi bilan bog'liq bo'lishi mumkin. Gipofiz apopleksiyasi to'satdan bosh og'rig'i, ko'rish buzilishi, oftalmoplegiya va gormonal yetishmovchilik bilan kechishi mumkin. Shuning uchun gemorragik komponent aniqlangan bemorlar alohida klinik nazoratni talab qiladi.

MRT asosidagi morfologik tahlil davolash natijalarini kuzatishda ham muhimdir. Operatsiyadan keyingi 3–6 oy oralig'ida kontrastli MRT o'tkazish qoldiq o'sma, rezeksiya hajmi va qaytalanish xavfini baholash imkonini beradi. Prolaktinomalarda dori terapiyasi fonida o'sma hajmining kamayishini volumetrik baholash davolash samaradorligini aniqlash uchun muhim mezon hisoblanadi. Umuman olganda, gipofiz makroadenomalarni baholashda multidisiplinar yondashuv talab etiladi. Neyroxirurg o'smaning operabelligi va xavfsiz rezeksiya chegaralarini, endokrinolog gormonal faollik va medikamentoz davolash imkoniyatlarini, radiolog esa o'smaning morfologik va topografik belgilarini baholashi kerak. Oftalmologik tekshiruv esa optik apparat zararlanish darajasini aniqlashda muhim o'rin tutadi.

5. XULOSA

Conclusion

Turli gormonal faollikka ega gipofiz makroadenomalari MRT-morfologik ko'rinishi, o'sish yo'nalishi va invazivlik darajasi bo'yicha bir-biridan farq qiladi. Gormonal nofaol makroadenomalari ko'proq suprasellar kengayish, optik xiazma kompressiyasi va kech klinik namoyon bo'lish bilan tavsiflanadi. Prolaktinomalar va somatotropinomalarda esa kavernoza sinusa lateral invaziya va parasellar o'sish nisbatan ko'proq uchrashi mumkin. MRT gipofiz makroadenomalari aniqlash, ularning morfologik tuzilishini baholash, jarrohlik xavfini aniqlash va davolash taktikasini individual tanlashda asosiy diagnostik usul hisoblanadi. O'smaning maksimal o'lchami bilan bir qatorda hajmi, Knosp darajasi, optik xiazma bilan munosabati, sfenoidal sinusa tarqalishi, ichki uyqu arteriyasi va gipofiz oyoqchasi bilan aloqasi batafsil baholanishi kerak. Knosp 3–4 darajali invaziv makroadenomalarda radikal rezeksiya ehtimoli kamayadi va qoldiq o'sma xavfi ortadi. Bunday bemorlarda davolash strategiyasi jarrohlik, medikamentoz davolash va radioterapiya imkoniyatlarini hisobga olgan holda multidisiplinar tarzda belgilanadi. Gormonal faollik va MRT-morfologik belgilarni birgalikda tahlil qilish gipofiz makroadenomalari biologik xatti-harakatini baholash, davolash natijalarini prognozlash va operatsiyadan keyingi kuzatuv rejasini tuzishda muhim ahamiyatga ega.

DECLARATIONS

Declarations

Author contributions *CRedit*

Conceptualization; Methodology; Investigation; Writing – original draft; Writing – review & editing. The author has read and agreed to the published version of the manuscript.

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Ethics approval

The study was approved by the local ethics committee of the Specialized Scientific and Practical Center for Neurosurgery and Neurorehabilitation at the Samarkand State Medical University.

Informed consent

Written informed consent was obtained from all patients for the use of their clinical data and for publication of the accompanying anonymised images.

Data availability statement

The data obtained in the study are presented in the tables and figures of this article; the primary records are available from the author on reasonable request.

Conflict of interest

The author declares no conflict of interest.

Generative AI disclosure

Generative AI (Claude, Anthropic) was used in the editorial preparation of this article: for language editing, translation of the title, abstract and keywords between Uzbek, Russian and English, preparation of the extended English summary from the author's text, and formatting of the reference list. No data, results or conclusions were generated by AI. The author is responsible for the content of the publication.

EXTENDED SUMMARY IN ENGLISH

Kengaytirilgan inglizcha xulosa / Расширенный реферат на английском языке

Purpose and research problem

Pituitary macroadenomas are among the most important space-occupying lesions of the sellar and parasellar region. Their clinical course depends not only on tumour size but also on hormonal activity, the direction of growth, invasion of the cavernous sinus, suprasellar extension and the relationship of the tumour to the optic chiasm.

Hormonally active adenomas produce characteristic endocrine syndromes, whereas non-functioning tumours often remain clinically silent until they reach a large volume and compress the visual pathways. Magnetic resonance imaging is the principal method for detecting these tumours, describing their topographic and anatomical spread and planning surgical tactics. The aim of the study was to describe the MRI-based morphological features and growth patterns of pituitary macroadenomas with different hormonal activity and to show how a structured MRI assessment supports the estimation of surgical risk and the individual choice of treatment.

Materials and methods

The work was designed as a retrospective clinical and radiological observation of patients with a diagnosis of pituitary macroadenoma. Clinical, endocrinological and MRI data were analysed, and the patients were grouped by hormonal activity: prolactinoma, somatotropinoma, corticotropinoma, thyrotropinoma, plurihormonal and non-functioning macroadenoma. Inclusion criteria were a sellar tumour of 10 mm or more in diameter, an available contrast-enhanced MRI study, laboratory assessment of the main pituitary hormones, clinical, neurological and ophthalmological data, and primary pre-treatment images suitable for analysis. Patients after previous sellar surgery or radiotherapy, other sellar-parasellar tumours (meningioma, craniopharyngioma, metastasis, germinoma, Rathke cleft cyst), poor-quality images and incomplete hormonal data were excluded. MRI was performed on 1.5 T or 3.0 T scanners with sagittal and coronal T1-weighted images, T2-weighted images, thin-section contrast-enhanced T1 images and, when needed, dynamic contrast sequences. The maximal craniocaudal, transverse and anteroposterior dimensions, tumour volume (ellipsoid formula: length × width × height × 0.52), suprasellar and parasellar extension, Knosp grade, optic chiasm compression, stalk deviation, cystic, necrotic and haemorrhagic changes and the relation to the sphenoid sinus were assessed. Hormonal activity was evaluated from prolactin, growth hormone, IGF-1, ACTH, cortisol, TSH, free T4, LH, FSH and sex steroid levels, together with visual acuity, perimetry and fundus findings. Quantitative variables were expressed as mean and standard deviation and qualitative variables as numbers and percentages; the χ^2 test, Fisher's test, Student's t-test or the Mann–Whitney U test could be applied, with $p < 0.05$ taken as significant.

Results and discussion

In the clinical and radiological model presented in the article, 72 patients were distributed by hormonal activity as follows: non-functioning macroadenoma 28 (38.9%), prolactinoma 18 (25.0%), somatotropinoma 14 (19.4%), corticotropinoma 5 (6.9%), thyrotropinoma 2 (2.8%) and plurihormonal macroadenoma 5 (6.9%). Non-functioning macroadenomas were usually large and grew upwards through the sellar diaphragm; headache, narrowing of the visual fields and general weakness were the main complaints, and compression of the optic chiasm was the leading radiological and clinical sign. Prolactinomas had a relatively large mean volume, showed lateral invasion into the cavernous sinus in some cases and sometimes contained cystic or haemorrhagic components; macroprolactinomas in men were detected late and reached a large size. Somatotropinomas were accompanied by acromegalic features, arterial hypertension and metabolic disorders and were in close contact with the medial wall of the cavernous sinus; Knosp grade 3 was regarded as a factor reducing the probability of surgical remission. Corticotropinomas were few but clinically severe, with hypercortisolism, hypertension, impaired glucose metabolism and weight gain, and were sometimes heterogeneous with parasellar extension. Tumour volume was directly related to optic chiasm compression, whereas cavernous sinus invasion did not always depend on the overall volume: some medium-sized functioning adenomas grew aggressively in a lateral direction. Knosp grades 0–2 predominated in non-functioning tumours, while grades 3–4 were relatively more frequent in prolactinomas and somatotropinomas. Stalk deviation was more common in non-functioning and large prolactin-secreting tumours and may explain moderate hyperprolactinaemia through the stalk effect. Heterogeneous structure reflected cystic degeneration, necrosis or haemorrhage, and haemorrhagic components indicated a risk of pituitary apoplexy. Suprasellar growth pointed to the need for decompression of the optic apparatus, parasellar invasion to the likelihood of residual tumour in the

cavernous sinus, and inferior extension to the sphenoid sinus influenced the choice of the transsphenoidal approach.

Conclusion and contribution

Pituitary macroadenomas with different hormonal activity differ in their MRI morphology, direction of growth and degree of invasiveness. Non-functioning macroadenomas are characterised mainly by suprasellar extension, optic chiasm compression and late clinical presentation, whereas prolactinomas and somatotropinomas more often show lateral invasion of the cavernous sinus and parasellar growth. Besides the maximal diameter, the radiological report should describe tumour volume, Knosp grade, the relation to the optic chiasm, extension into the sphenoid sinus and the relation to the internal carotid artery and the pituitary stalk. In invasive Knosp 3–4 tumours the probability of radical resection decreases and the risk of residual tumour increases, so treatment should be planned by a multidisciplinary team combining surgery, medical therapy and radiotherapy. Joint analysis of hormonal activity and MRI morphological features helps to assess tumour behaviour, predict treatment outcomes and plan postoperative follow-up.

ADABIYOTLAR RO'YXATI

References (original language)

- [1] Urmanova, Y. M., Sodikov, S. P., Kim, M., Dushanov, T. A., & Mukhtarova, Sh. Sh. (2019). The frequency and neuroimaging characteristics of macro- and giant pituitary adenomas. *International Journal of Biomedicine*, 9(1), 72–74. DOI: 10.21103/Article9(1)_ShC1
- [2] Urmanova, Y. M., Rikhsiyeva, N. T., Tashmanova, A. B., Mirtukhtaeva, M. B., & Urmanova, F. M. (2026). Neuro-imaging characteristics of patients with giant non-functional pituitary adenomas. *Biomedical Journal of Scientific & Technical Research*, 64(4), 56954–56960. DOI: 10.26717/BJSTR.2026.64.010101
- [3] Khalimova, Z. Yu., Kholova, D. Sh., Urmanova, Yu. M., Faizullaev, R. B., Alieva, D. A., Alimukhamedova, G. O., Karimova, M. M., & Safarova, Sh. M. (2013). Изучение особенностей семейного наследования неактивных аденом гипофиза в Республике Узбекистан. *Международный эндокринологический журнал*, 1(49). DOI: 10.22141/2224-0721.1.49.2013.84047
- [4] Khalimova, Z. Yu., Kholova, D. Sh., Khamedova, F. S., & Alieva, D. A. (2013). Особенности клинического течения и диагностика больных с семейным анамнезом неактивных аденом гипофиза. *Международный эндокринологический журнал*, 4(52), 28–36.
- [5] Urmanova, Yu. M., & Alimova, K. B. (2016). Нейровизуализационная характеристика гигантских аденом гипофиза в зависимости от механического фактора. *Международный эндокринологический журнал*, 4, 100–103.
- [6] Urmanova, Yu. M., Shakirova, M. Yu., Rikhsiyeva, N. T., & Khodjaeva, F. S. (2019). Факторы риска рецидива неактивных аденом гипофиза у больных с дефицитом гормона роста. *Международный эндокринологический журнал*, 15(2), 46–50.
- [7] Urmanova, Yu. M., Khalimova, Z. Yu., & Faizullaev, R. B. (2015). Значение определения клинико-диагностических маркеров агрессивности неактивных аденом гипофиза. *Международный эндокринологический журнал*, 6(70), 24–27.
- [8] Urmanova, Yu. M., & Alimova, K. B. (2018). Гигантские аденомы гипофиза: распространенность, особенности диагностики и клинического течения. *Международный эндокринологический журнал*, 14(5), 539–542.
- [9] Faizullaev, R. B. (2009). Гигантские аденомы гипофиза: клиника, диагностика, хирургическое лечение [Докторская диссертация]. Москва.
- [10] Kadashev, B. A. (2007). Аденомы гипофиза: клиника, диагностика, лечение. Тверь.
- [11] Kalinin, P. L., Sharipov, O. I., Pronin, I. N., Kutin, M. A., Fomichev, D. V., Kadashev, B. A., Shkarubo, A. N., Alekseev, S. N., Astaf'eva, L. I., Tropinskaya, O. F., Dobrovol'skiy, G. F., Shults, E. I., Andreev, D. N., Voronina, I. A., & Kurnosov, A. B. (2016). Endoscopic transsphenoidal resection of pituitary adenomas invading the cavernous sinus. *Burdenko's Journal of Neurosurgery*, 80(4), 63–74. DOI: 10.17116/neiro201680463-74
- [12] Kalinin, P. L., Kadashev, B. A., Fomichev, D. V., Kutin, M. A., Astaf'eva, L. I., Sharipov, O. I., Shkarubo, A. N., Tropinskaya, O. F., Voronina, I. A., & Fomochkina, L. A. (2017). Surgical treatment for pituitary adenomas. *Burdenko's Journal of Neurosurgery*, 81(1), 95–107. DOI: 10.17116/neiro201780795-107
- [13] Eremkina, A. K., Dzeranova, L. K., Pigarova, E. K., Mokrysheva, N. G., & Dedov, I. I. (2019). Morphofunctional features of non-functioning pituitary adenomas. *Russian Journal of Archive of Pathology*, 81(1), 71–78. DOI: 10.17116/ptol20198101171
- [14] Fedorova, N. S., Abrosimov, A. Iu., Dzeranova, L. K., Pigarova, E. A., & Dedov, I. I. (2018). Pituitary lactotroph adenomas resistant to dopamine agonist treatment: Histological and immunohistochemical characteristics. *Russian Journal of Archive of Pathology*, 80(3), 34–39. DOI: 10.17116/ptol201880334-39
- [15] Ilovayskaya, I. A., Dreval, A. V., Krivosheeva, Yu. G., et al. (2016). Особенности роста макроадеом гипофиза с различной гормональной активностью. *Альманах клинической медицины*, 44(4), 451–456.
- [16] Astaf'eva, L. I., Kadashev, B. A., & Kalinin, P. L. (2017). Развитие назальной ликвореи у молодой женщины с гигантской пролактиномой через 6,5 лет терапии каберголином. *Эндокринная хирургия*, 11(4), 201–208.
- [17] Astaf'eva, L. I., Kalinin, P. L., Kadashev, B. A., et al. (2009). Выбор тактики лечения гигантских пролактинсекретирующих аденом гипофиза. *Вопросы нейрохирургии имени Н. Н. Бурденко*, 2, 23–29.
- [18] Kadashev, B. A., Kutin, M. A., Kalinin, P. L., Trunin, Yu. K., Alekseev, S. N., & Shkarubo, A. N. (2004). Сравнительная оценка результатов хирургического лечения пациентов с аденомами гипофиза, инфильтрирующими кавернозный синус. *Вопросы нейрохирургии имени Н. Н. Бурденко*, 3, 14–17.
- [19] Shkarubo, A. N., Shishkina, L. V., Serova, N. K., et al. (2015). Эндоскопическое эндоназальное удаление крупной аденомы гипофиза, распространяющейся в заднюю черепную ямку. *Вопросы нейрохирургии имени Н. Н. Бурденко*, 79(6), 85–91.
- [20] Kalinin, P. L., Shkarubo, A. N., Astaf'eva, L. I., et al. (2017). Назальная ликворея при первичном лечении больших и гигантских пролактином агонистами дофамина. *Вопросы нейрохирургии имени Н. Н. Бурденко*, 81(6), 32–39.
- [21] Asa, S. L., Mete, O., Perry, A., & Osamura, R. Y. (2022). Overview of the 2022 WHO classification of pituitary tumors. *Endocrine Pathology*, 33, 6–26. DOI: 10.1007/s12022-022-09703-7
- [22] Casar-Borota, O., Asioli, S., & Mete, O. (2024). The 2022 WHO classification of tumors of the pituitary gland. *Brain Pathology*, 34, e13302. DOI: 10.1111/bpa.13302
- [23] Tsukamoto, T., Miki, Y., & Takahashi, J. A. (2023). Imaging of pituitary tumors: An update with the 5th WHO classification. *Japanese Journal of Radiology*, 41, 789–806. DOI: 10.1007/s11604-023-01402-9
- [24] Knosp, E., Steiner, E., Kitz, K., & Matula, C. (1993). Pituitary adenomas with invasion of the cavernous sinus space: A magnetic resonance imaging classification compared with surgical findings. *Neurosurgery*, 33(4), 610–618. DOI: 10.1227/00006123-199310000-00008
- [25] Cottier, J. P., Destrieux, C., Brunereau, L., Bertrand, P., Moreau, L., Jan, M., & Herbreteau, D. (2000). Cavernous sinus invasion by pituitary adenoma: MR imaging. *Radiology*, 215(2), 463–469. DOI: 10.1148/radiology.215.2.r00ap18463
- [26] Micko, A. S. G., Wöhrer, A., Wolfsberger, S., & Knosp, E. (2015). Invasion of the cavernous sinus space in pituitary adenomas: Endoscopic verification and its correlation with an MRI-based classification. *Journal of Neurosurgery*, 122(4), 803–811. DOI: 10.3171/2014.12.JNS141083
- [27] Seroli, S., Doglietto, F., Fiorindi, A., Biroli, A., Mattavelli, D., Buffoli, B., & Fontanella, M. M. (2019). Pituitary adenomas and invasiveness from anatomico-surgical, radiological, and histological perspectives: A systematic literature review. *Cancers*, 11(12), 1936. DOI: 10.3390/cancers11121936
- [28] Pereira, F. V., Chaddad Neto, F., & colleagues. (2025). Pituitary macroadenoma: Less common neuroimaging features in a common lesion. *Radiologia Brasileira*, 58, e20240048.
- [29] Eisenhut, F., Schlaffer, S. M., Hirt, B., et al. (2022). Improved detection of cavernous sinus invasion of pituitary macroadenomas with

- ultra-high-field 7 T MRI. *Cancers*, 14(1), 162. DOI: 10.3390/cancers14010162
- [30] Gruppetta, M., & Vassallo, J. (2016). Epidemiology and radiological geometric assessment of pituitary macroadenomas: Population-based study. *Clinical Endocrinology*, 85(2), 223–231. DOI: 10.1111/cen.13064
- [31] Freda, P. U., Beckers, A. M., Katznelson, L., Molitch, M. E., Montori, V. M., Post, K. D., & Vance, M. L. (2011). Pituitary incidentaloma: An Endocrine Society clinical practice guideline. *Journal of Clinical Endocrinology & Metabolism*, 96(4), 894–904. DOI: 10.1210/jc.2010-1048
- [32] Petersenn, S., Fleseriu, M., Casanueva, F. F., et al. (2023). Diagnosis and management of prolactin-secreting pituitary adenomas: A Pituitary Society international consensus statement. *Nature Reviews Endocrinology*, 19, 722–740. DOI: 10.1038/s41574-023-00886-5
- [33] Fleseriu, M., Biller, B. M. K., Freda, P. U., et al. (2021). A Pituitary Society update to acromegaly management guidelines. *Pituitary*, 24, 1–13. DOI: 10.1007/s11102-020-01091-7
- [34] Drummond, J. B., Ribeiro-Oliveira, A., & Soares, B. S. (2022). Non-functioning pituitary adenomas. In K. R. Feingold, B. Anawalt, M. R. Blackman, et al. (Eds.), *Endotext*. MDText.com.
- [35] Molitch, M. E. (2017). Diagnosis and treatment of pituitary adenomas: A review. *JAMA*, 317(5), 516–524. DOI: 10.1001/jama.2016.19699
- [9] Faizullaev, R. B. (2009). Gigantskie adenomy gipofiza: klinika, diagnostika, khirurgicheskoe lechenie [Giant pituitary adenomas: clinical picture, diagnosis, surgical treatment] [Doctoral dissertation]. Moskva. (in Russian)
- [10] Kadashev, B. A. (2007). Adenomy gipofiza: klinika, diagnostika, lechenie [Pituitary adenomas: clinical picture, diagnosis, treatment]. Tver'. (in Russian)
- [11] Kalinin, P. L., Sharipov, O. I., Pronin, I. N., Kutin, M. A., Fomichev, D. V., Kadashev, B. A., Shkarubo, A. N., Alekseev, S. N., Astaf'eva, L. I., Tropinskaya, O. F., Dobrovolskiy, G. F., Shults, E. I., Andreev, D. N., Voronina, I. A., & Kurnosov, A. B. (2016). Endoscopic transsphenoidal resection of pituitary adenomas invading the cavernous sinus. *Burdenko's Journal of Neurosurgery*, 80(4), 63–74. DOI: 10.17116/neiro201680463-74
- [12] Kalinin, P. L., Kadashev, B. A., Fomichev, D. V., Kutin, M. A., Astaf'eva, L. I., Sharipov, O. I., Shkarubo, A. N., Tropinskaya, O. F., Voronina, I. A., & Fomochkina, L. A. (2017). Surgical treatment for pituitary adenomas. *Burdenko's Journal of Neurosurgery*, 81(1), 95–107. DOI: 10.17116/neiro201780795-107
- [13] Eremkina, A. K., Dzeranova, L. K., Pigarova, E. K., Mokrysheva, N. G., & Dedov, I. I. (2019). Morphofunctional features of non-functioning pituitary adenomas. *Russian Journal of Archive of Pathology*, 81(1), 71–78. DOI: 10.17116/ptol20198101171
- [14] Fedorova, N. S., Abrosimov, A. Iu., Dzeranova, L. K., Pigarova, E. A., & Dedov, I. I. (2018). Pituitary lactotroph adenomas resistant to dopamine agonist treatment: Histological and immunohistochemical characteristics. *Russian Journal of Archive of Pathology*, 80(3), 34–39. DOI: 10.17116/ptol201880334-39
- [15] Ilovayskaya, I. A., Dreval, A. V., Krivosheeva, Yu. G., et al. (2016). Osobennosti rosta makroadenom gipofiza s razlichnoy gormonal'noy aktivnost'yu [Growth features of pituitary macroadenomas with different hormonal activity]. *Al'manakh klinicheskoy meditsiny*, 44(4), 451–456. (in Russian)
- [16] Astaf'eva, L. I., Kadashev, B. A., & Kalinin, P. L. (2017). Razvitiye nazal'noy likvorei u molodoy zhenshchiny s gigantskoy prolaktinomoy cherez 6,5 let terapii kabergolinom [Development of nasal liquorrhea in a young woman with a giant prolactinoma after 6.5 years of cabergoline therapy]. *Endokrinnaya khirurgiya*, 11(4), 201–208. (in Russian)
- [17] Astaf'eva, L. I., Kalinin, P. L., Kadashev, B. A., et al. (2009). Vybortaktiki lecheniya gigantskikh prolaktinsekretyuyushchikh adenom gipofiza [Choice of treatment strategy for giant prolactin-secreting pituitary adenomas]. *Voprosy neyrokhirurgii imeni N. N. Burdenko*, 2, 23–29. (in Russian)
- [18] Kadashev, B. A., Kutin, M. A., Kalinin, P. L., Trunin, Yu. K., Alekseev, S. N., & Shkarubo, A. N. (2004). Sravnitel'naya otsenka rezul'tatov khirurgicheskogo lecheniya patsientov s adenomami gipofiza, infil'triruyushchimi kavernozyy sinus [Comparative evaluation of the results of surgical treatment of patients with pituitary adenomas infiltrating the cavernous sinus]. *Voprosy neyrokhirurgii imeni N. N. Burdenko*, 3, 14–17. (in Russian)
- [19] Shkarubo, A. N., Shishkina, L. V., Serova, N. K., et al. (2015). Endoskopicheskoe endonazal'noe udalenie krupnoy adenomy gipofiza, rasprostranyayushchetsya v zadnyuyu cherepnuyu yamku [Endoscopic endonasal removal of a large pituitary adenoma extending into the posterior cranial fossa]. *Voprosy neyrokhirurgii imeni N. N. Burdenko*, 79(6), 85–91. (in Russian)
- [20] Kalinin, P. L., Shkarubo, A. N., Astaf'eva, L. I., et al. (2017). Nazal'naya likvoreya pri pervichnom lechenii bol'shikh i gigantskikh prolaktinom agonistami dofamina [Nasal liquorrhea during primary treatment of large and giant prolactinomas with dopamine agonists]. *Voprosy neyrokhirurgii imeni N. N. Burdenko*, 81(6), 32–39. (in Russian)
- [21] Asa, S. L., Mete, O., Perry, A., & Osamura, R. Y. (2022). Overview of the 2022 WHO classification of pituitary tumors. *Endocrine Pathology*, 33, 6–26. DOI: 10.1007/s12022-022-09703-7
- [22] Casar-Borota, O., Asioli, S., & Mete, O. (2024). The 2022 WHO classification of tumors of the pituitary gland. *Brain Pathology*, 34, e13302. DOI: 10.1111/bpa.13302
- [23] Tsukamoto, T., Miki, Y., & Takahashi, J. A. (2023). Imaging of pituitary tumors: An update with the 5th WHO classification. *Japanese Journal of Radiology*, 41, 789–806. DOI: 10.1007/s11604-023-01402-9

REFERENCES (ROMAN SCRIPT)

Transliterated list — required by Scopus and Web of Science

- [1] Urmanova, Y. M., Sodikov, S. P., Kim, M., Dushanov, T. A., & Mukhtarova, Sh. Sh. (2019). The frequency and neuroimaging characteristics of macro- and giant pituitary adenomas. *International Journal of Biomedicine*, 9(1), 72–74. DOI: 10.21103/Article9(1)_ShC1
- [2] Urmanova, Y. M., Rikhsiyeva, N. T., Tashmanova, A. B., Mirtukhtaeva, M. B., & Urmanova, F. M. (2026). Neuro-imaging characteristics of patients with giant non-functional pituitary adenomas. *Biomedical Journal of Scientific & Technical Research*, 64(4), 56954–56960. DOI: 10.26717/BJSTR.2026.64.010101
- [3] Khalimova, Z. Yu., Kholova, D. Sh., Urmanova, Yu. M., Faizullaev, R. B., Alieva, D. A., Alimukhamedova, G. O., Karimova, M. M., & Safarova, Sh. M. (2013). Izuchenie osobennostey semeynogo nasledovaniya neaktivnykh adenom gipofiza v Respublike Uzbekistan [Study of the features of familial inheritance of non-functioning pituitary adenomas in the Republic of Uzbekistan]. *Mezhdunarodnyy endokrinologicheskij zhurnal*, 1(49). DOI: 10.22141/2224-0721.1.49.2013.84047 (in Russian)
- [4] Khalimova, Z. Yu., Kholova, D. Sh., Khamedova, F. S., & Alieva, D. A. (2013). Osobennosti klinicheskogo techeniya i diagnostika bol'nykh s semeynym anamnezom neaktivnykh adenom gipofiza [Clinical course and diagnosis in patients with a family history of non-functioning pituitary adenomas]. *Mezhdunarodnyy endokrinologicheskij zhurnal*, 4(52), 28–36. (in Russian)
- [5] Urmanova, Yu. M., & Alimova, K. B. (2016). Neyrovizualizatsionnaya kharakteristika gigantskikh adenom gipofiza v zavisimosti ot mekhanicheskogo faktora [Neuroimaging characteristics of giant pituitary adenomas depending on the mechanical factor]. *Mezhdunarodnyy endokrinologicheskij zhurnal*, 4, 100–103. (in Russian)
- [6] Urmanova, Yu. M., Shakirova, M. Yu., Rikhsiyeva, N. T., & Khodjaeva, F. S. (2019). Faktory riska retsidiva neaktivnykh adenom gipofiza u bol'nykh s defitsitom gormona rosta [Risk factors for recurrence of non-functioning pituitary adenomas in patients with growth hormone deficiency]. *Mezhdunarodnyy endokrinologicheskij zhurnal*, 15(2), 46–50. (in Russian)
- [7] Urmanova, Yu. M., Khalimova, Z. Yu., & Faizullaev, R. B. (2015). Znachenie opredeleniya kliniko-diagnosticheskikh markerov aggressivnosti neaktivnykh adenom gipofiza [Significance of determining clinical and diagnostic markers of aggressiveness of non-functioning pituitary adenomas]. *Mezhdunarodnyy endokrinologicheskij zhurnal*, 6(70), 24–27. (in Russian)
- [8] Urmanova, Yu. M., & Alimova, K. B. (2018). Gigantskie adenomy gipofiza: rasprostranennost', osobennosti diagnostiki i klinicheskogo techeniya [Giant pituitary adenomas: prevalence, diagnostic features and clinical course]. *Mezhdunarodnyy endokrinologicheskij zhurnal*, 14(5), 539–542. (in Russian)

- [24] Knosp, E., Steiner, E., Kitz, K., & Matula, C. (1993). Pituitary adenomas with invasion of the cavernous sinus space: A magnetic resonance imaging classification compared with surgical findings. *Neurosurgery*, 33(4), 610–618. DOI: 10.1227/00006123-199310000-00008
- [25] Cottier, J. P., Destrieux, C., Brunereau, L., Bertrand, P., Moreau, L., Jan, M., & Herbreteau, D. (2000). Cavernous sinus invasion by pituitary adenoma: MR imaging. *Radiology*, 215(2), 463–469. DOI: 10.1148/radiology.215.2.r00ap18463
- [26] Micko, A. S. G., Wöhrer, A., Wolfsberger, S., & Knosp, E. (2015). Invasion of the cavernous sinus space in pituitary adenomas: Endoscopic verification and its correlation with an MRI-based classification. *Journal of Neurosurgery*, 122(4), 803–811. DOI: 10.3171/2014.12.JNS141083
- [27] Seriola, S., Doglietto, F., Fiorindi, A., Biroli, A., Mattavelli, D., Buffoli, B., & Fontanella, M. M. (2019). Pituitary adenomas and invasiveness from anatomic-surgical, radiological, and histological perspectives: A systematic literature review. *Cancers*, 11(12), 1936. DOI: 10.3390/cancers11121936
- [28] Pereira, F. V., Chaddad Neto, F., & colleagues. (2025). Pituitary macroadenoma: Less common neuroimaging features in a common lesion. *Radiologia Brasileira*, 58, e20240048.
- [29] Eisenhut, F., Schlaffer, S. M., Hirt, B., et al. (2022). Improved detection of cavernous sinus invasion of pituitary macroadenomas with ultra-high-field 7 T MRI. *Cancers*, 14(1), 162. DOI: 10.3390/cancers14010162
- [30] Gruppeta, M., & Vassallo, J. (2016). Epidemiology and radiological geometric assessment of pituitary macroadenomas: Population-based study. *Clinical Endocrinology*, 85(2), 223–231. DOI: 10.1111/cen.13064
- [31] Freda, P. U., Beckers, A. M., Katznelson, L., Molitch, M. E., Montori, V. M., Post, K. D., & Vance, M. L. (2011). Pituitary incidentaloma: An Endocrine Society clinical practice guideline. *Journal of Clinical Endocrinology & Metabolism*, 96(4), 894–904. DOI: 10.1210/jc.2010-1048
- [32] Petersenn, S., Fleseriu, M., Casanueva, F. F., et al. (2023). Diagnosis and management of prolactin-secreting pituitary adenomas: A Pituitary Society international consensus statement. *Nature Reviews Endocrinology*, 19, 722–740. DOI: 10.1038/s41574-023-00886-5
- [33] Fleseriu, M., Biller, B. M. K., Freda, P. U., et al. (2021). A Pituitary Society update to acromegaly management guidelines. *Pituitary*, 24, 1–13. DOI: 10.1007/s11102-020-01091-7
- [34] Drummond, J. B., Ribeiro-Oliveira, A., & Soares, B. S. (2022). Non-functioning pituitary adenomas. In K. R. Feingold, B. Anawalt, M. R. Blackman, et al. (Eds.), *Endotext*. MDTText.com.
- [35] Molitch, M. E. (2017). Diagnosis and treatment of pituitary adenomas: A review. *JAMA*, 317(5), 516–524. DOI: 10.1001/jama.2016.19699