

UNIVERSITY MOHAMMED V - RABAT
FACULTY OF MEDICINE AND PHARMACY RABAT

YEAR: 2017

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**ANTERIOR AND MIDDLE SKULL BASE FOSSA MENINGIOMAS
(EXPERIENCE OF DEPARTMENT OF NEUROSURGERY)
(HÔPITAL DES SPECIALITES - RABAT)
SINGLE CENTER COHORT OF 100 CONSECUTIVE PATIENTS**

THESIS

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By

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Born September 21st, 1990 in Rabat

For the degree of medicine doctor

KEY WORDS: Skull base meningiomas – Anterior middle fossa – Classification –
Surgery – Prognosis.

JURY

M. A. EL OUAHABI

Professor of Neurosurgery

M. ADNAOUI MOHAMED

Professor of Internal Medicine

Mrs. M. BOUTARBOUCH

Professor of Neurosurgery

M. Y. ARKHA

Professor of Neurosurgery

M. A. MELHAOUI

Professor of Neurosurgery

M. S. KABBAJ

Professor of Anesthesiology and Reanimation

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HONORARY PRESIDENT

DIRECTOR

**JURY
MEMBERS**

LIST OF PROFESSORS



**UNIVERSITE MOHAMMED V DE RABAT
FACULTE DE MEDECINE ET DE PHARMACIE - RABAT**

DOYENS HONORAIRES :

1962 – 1969 : Professeur Abdelmalek FARAJ
1969 – 1974 : Professeur Abdellatif BERBICH
1974 – 1981 : Professeur Bachir LAZRAK
1981 – 1989 : Professeur Taieb CHKILI
1989 – 1997 : Professeur Mohamed Tahar ALAOUI
1997 – 2003 : Professeur Abdelmajid BELMAHI
2003 – 2013 : Professeur Najia HAJJAJ - HASSOUNI



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Professeur Mohammed AHALLAT
Vice Doyen chargé de la Recherche et de la Coopération
Professeur Taoufiq DAKKA
Vice Doyen chargé des Affaires Spécifiques à la Pharmacie
Professeur Jamal TAOUFIK
Secrétaire Général : Mr. Mohamed KARRA

**1- ENSEIGNANTS-CHERCHEURS MEDECINS
ET
PHARMACIENS**

PROFESSEURS :

Décembre 1984

Pr. MAAOUNI Abdelaziz
Pr. MAAZOUZI Ahmed Wajdi
Pr. SETTAF Abdellatif

Médecine Interne – **Clinique Royale**
Anesthésie -Réanimation
pathologie Chirurgicale

Novembre et Décembre 1985

Pr. BENSAID Younes

Pathologie Chirurgicale

Janvier, Février et Décembre 1987

Pr. CHAHED OUZZANI Houria
Pr. LACHKAR Hassan
Pr. YAHYAOUY Mohamed

Gastro-Entérologie
Médecine Interne
Neurologie

Décembre 1988

Pr. BENHAMAMOUCH Mohamed Najib
Pr. DAFIRI Rachida

Chirurgie Pédiatrique
Radiologie

Décembre 1989

Pr. ADNABOU Mohamed
Pr. CHAD Bouziane
Pr. OUZZANI Taïbi Mohamed Réda

Janvier et Novembre 1990

Pr. CHKOFF Rachid
Pr. HACHIM Mohammed*
Pr. KHARBACH Aïcha
Pr. MANSOURI Fatima
Pr. TAZI Saoud Anas

Février Avril Juillet et Décembre 1991

Pr. AL HAMANY Zaïtounia
Pr. AZZOUZI Abderrahim
Pr. BAYAHIA Rabéa
Pr. BELKOUCHI Abdelkader
Pr. BENCHEKROUN Belabbes Abdellatif
Pr. BENSOUDA Yahia
Pr. BERRAHO Amina
Pr. BEZZAD Rachid
Pr. CHABRAOUI Layachi
Pr. CHERRAH Yahia
Pr. CHOKAIRI Omar
Pr. KHATTAB Mohamed
Pr. SOULAYMANI Rachida
Pr. TAOUFIK Jamal

Décembre 1992

Pr. AHALLAT Mohamed
Pr. BENSOUDA Adil
Pr. BOUJIDA Mohamed Najib
Pr. CHAHED OUZZANI Laaziza
Pr. CHRAIBI Chafiq
Pr. DEHAYNI Mohamed*
Pr. EL OUAHABI Abdessamad
Pr. FELLAT Rokaya
Pr. GHAFIR Driss*
Pr. JIDDANE Mohamed
Pr. TAGHY Ahmed
Pr. ZOUHDI Mimoun

Médecine Interne – **Doyen de la FMPR**

Pathologie Chirurgicale
Neurologie

Pathologie Chirurgicale
Médecine-Interne
Gynécologie -Obstétrique
Anatomie-Pathologique
Anesthésie Réanimation

Anatomie-Pathologique
Anesthésie Réanimation – **Doyen de la FMPO**

Néphrologie
Chirurgie Générale
Chirurgie Générale
Pharmacie galénique
Ophtalmologie
Gynécologie Obstétrique
Biochimie et Chimie
Pharmacologie
Histologie Embryologie
Pédiatrie

Pharmacologie – **Dir. du Centre National PV**
Chimie thérapeutique **V.D à la pharmacie+Dir du CEDOC**

Chirurgie Générale V.D Aff. Acad. et Estud
Anesthésie Réanimation
Radiologie
Gastro-Entérologie
Gynécologie Obstétrique
Gynécologie Obstétrique
Neurochirurgie
Cardiologie
Médecine Interne
Anatomie
Chirurgie Générale
Microbiologie



Mars 1994

Pr. BENJAAFAR Nouredine
Pr. BEN RAIS Nozha
Pr. CAOUI Malika
Pr. CHRAIBI Abdelmjid

Pr. EL AMRANI Sabah
Pr. EL BARDOUNI Ahmed
Pr. EL HASSANI My Rachid
Pr. ERROUGANI Abdelkader
Pr. ESSAKALI Malika
Pr. ETTAYEBI Fouad
Pr. HADRI Larbi*
Pr. HASSAM Badredine
Pr. IFRINE Lahssan
Pr. JELTHI Ahmed
Pr. MAHFOUD Mustapha
Pr. RHRAB Brahim
Pr. SENOUCI Karima

Mars 1994

Pr. ABBAR Mohamed*
Pr. ABDELHAK M'barek
Pr. BELAIDI Halima
Pr. BENTAHILA Abdelali
Pr. BENYAHIA Mohammed Ali
Pr. BERRADA Mohamed Saleh
Pr. CHAMI Ilham
Pr. CHERKAoui Lalla Ouafae
Pr. JALIL Abdelouahed
Pr. LAKHDAR Amina
Pr. MOUANE Nezha

Mars 1995

Pr. ABOUQUAL Redouane
Pr. AMRAoui Mohamed
Pr. BAIDADA Abdelaziz
Pr. BARGACH Samir
Pr. CHAARI Jilali*

Radiothérapie
Biophysique
Biophysique
Endocrinologie et Maladies Métaboliques

Doyen de la FMPA

Gynécologie Obstétrique
Traumato-Orthopédie
Radiologie
Chirurgie Générale- **Directeur CHIS**
Immunologie
Chirurgie Pédiatrique
Médecine Interne
Dermatologie
Chirurgie Générale
Anatomie Pathologique
Traumatologie – Orthopédie
Gynécologie – Obstétrique
Dermatologie

Urologie
Chirurgie – Pédiatrique
Neurologie
Pédiatrie
Gynécologie – Obstétrique
Traumatologie – Orthopédie
Radiologie
Ophtalmologie
Chirurgie Générale
Gynécologie Obstétrique
Pédiatrie



Réanimation Médicale
Chirurgie Générale
Gynécologie Obstétrique
Gynécologie Obstétrique
Médecine Interne

Pr. DIMOU M'barek*
Pr. DRISSI KAMILI Med Nordine*
Pr. EL MESNAOUI Abbes
Pr. ESSAKALI HOUSSEINI Leila
Pr. HDA Abdelhamid*
Pr. IBEN ATTYA ANDALOUSSI Ahmed
Pr. OUAZZANI CHAHDI Bahia
Pr. SEFIANI Abdelaziz
Pr. ZEGGWAGH Amine Ali

Anesthésie Réanimation
Anesthésie Réanimation
Chirurgie Générale
Oto-Rhino-Laryngologie
Cardiologie - **Directeur HMI Med V**
Urologie
Ophtalmologie
Génétique
Réanimation Médicale

Décembre 1996

Pr. AMIL Touriya*
Pr. BELKACEM Rachid
Pr. BOULANOUAR Abdelkrim
Pr. EL ALAMI EL FARICHA EL Hassan
Pr. GAOUZI Ahmed
Pr. MAHFOUDI M'barek*
Pr. OUADGHIRI Mohamed
Pr. OUZEDDOUN Naima
Pr. ZBIR EL Mehdi*

Radiologie
Chirurgie Pédiatrie
Ophtalmologie
Chirurgie Générale
Pédiatrie
Radiologie
Traumatologie-Orthopédie
Néphrologie
Cardiologie

Novembre 1997

Pr. ALAMI Mohamed Hassan
Pr. BEN SLIMANE Lounis
Pr. BIROUK Nazha
Pr. ERREIMI Naima
Pr. FELLAT Nadia
Pr. HAIMEUR Charki*
Pr. KADDOURI Noureddine
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Pr. YOUSFI MALKI Mounia

Gynécologie-Obstétrique
Urologie
Neurologie
Pédiatrie
Cardiologie
Anesthésie Réanimation
Chirurgie Pédiatrique
Urologie
Chirurgie Générale
Pédiatrie
Psychiatrie
Gynécologie Obstétrique

Novembre 1998

Pr. AFIFI RAJAA
Pr. BENOMAR ALI
Pr. BOUGTAB Abdesslam

Gastro-Entérologie
Neurologie – **Doyen de la FMP Abulcassis**
Chirurgie Générale

Pr. ER RIHANI Hassan
Pr. BENKIRANE Majid*
Pr. KHATOURI ALI*

Janvier 2000

Pr. ABID Ahmed*
Pr. AIT OUMAR Hassan
Pr. BENJELLOUN Dakhama Badr.Sououd
Pr. BOURKADI Jamal-Eddine
Pr. CHARIF CHEFCHAOUNI Al Montacer
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Pr. EL FTOUH Mustapha
Pr. EL MOSTARCHID Brahim*
Pr. ISMAILI Hassane*
Pr. MAHMOUDI Abdelkrim*
Pr. TACHINANTE Rajae
Pr. TAZI MEZALEK Zoubida

Novembre 2000

Pr. AIDI Saadia
Pr. AJANA Fatima Zohra
Pr. BENAMR Said
Pr. CHERTI Mohammed
Pr. ECH-CHERIF EL KETTANI Selma
Pr. EL HASSANI Amine
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Pr. MAHASSINI Najat
Pr. MDAGHRI ALAOUI Asmae
Pr. ROUIMI Abdelhadi*

Décembre 2000

Pr. ZOHAIR ABDELAH*

Décembre 2001

Pr. BALKHI Hicham*
Pr. BENABDELJLIL Maria
Pr. BENAMAR Loubna

Oncologie Médicale
Hématologie
Cardiologie

Pneumophtisiologie
Pédiatrie
Pédiatrie
Pneumo-phtisiologie
Chirurgie Générale
Chirurgie Générale
Pneumo-phtisiologie
Neurochirurgie
Traumatologie Orthopédie- Dir. Hop. Av. Marr.
Anesthésie-Réanimation Inspecteur du SSM
Anesthésie-Réanimation
Médecine Interne

Neurologie
Gastro-Entérologie
Chirurgie Générale
Cardiologie
Anesthésie-Réanimation
Pédiatrie Directeur Hop. Chekikh Zaied
Urologie
Rhumatologie
Endocrinologie et Maladies Métaboliques
Anatomie Pathologique
Pédiatrie
Neurologie

ORL

Anesthésie-Réanimation
Neurologie
Néphrologie



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Décembre 2002

Pr. AL BOUZIDI Abderrahmane*
Pr. AMEUR Ahmed *
Pr. AMRI Rachida
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Pr. BELMEJDOUB Ghizlene*
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Pr. BENZZOUBEIR Nadia

Pneumo-phtisiologie
Gastro-Entérologie
Cardiologie
Pédiatrie
Rhumatologie
Anatomie
Radiologie
Radiologie
Chirurgie Générale
Radiologie
Anesthésie-Réanimation
Neuro-Chirurgie
Chirurgie-Pédiatrique
Chirurgie Générale
Pédiatrie **Directeur. Hop.d'Enfants**
Neuro-Chirurgie
Chirurgie Générale
Anesthésie-Réanimation
Chirurgie Thoracique
Traumatologie Orthopédie
Chirurgie Vasculaire Périphérique
Médecine Interne
Chirurgie Générale
Hématologie Clinique
Chirurgie Générale
Urologie **Directeur Hôpital Ibn Sina**
Chirurgie Générale
Chirurgie Vasculaire Périphérique
Pédiatrie



Anatomie Pathologique
Urologie
Cardiologie
Gastro-Entérologie
Biochimie-Chimie
Endocrinologie et Maladies Métaboliques
Dermatologie
Gastro-Entérologie

Pr. BERNOUSSI Zakiya
Pr. BICHRA Mohamed Zakariya*
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Pr. HAJJI Zakia
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Pr. ZENTAR Aziz*

Janvier 2004

Pr. ABDELLAH El Hassan
Pr. AMRANI Mariam
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Pr. BENKIRANE Ahmed*
Pr. BOUGHALEM Mohamed*
Pr. BOULAADAS Malik
Pr. BOURAZZA Ahmed*
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Pr. EL FENNI Jamal*
Pr. EL HANCHI ZAKI
Pr. EL KHORASSANI Mohamed
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Pr. HACHI Hafid
Pr. JABOUIRIK Fatima

Anatomie Pathologique
Psychiatrie
Chirurgie Générale
Pédiatrie
Chirurgie Pédiatrique
Dermatologie
Gynécologie Obstétrique
Ophtalmologie
Urologie
Traumatologie Orthopédie
Pédiatrie
Ophtalmologie
Traumatologie Orthopédie
Gynécologie Obstétrique
Oto-Rhino-Laryngologie
Traumatologie Orthopédie
Chirurgie Générale
Pneumophtisiologie
Néphrologie
Anesthésie Réanimation
Pédiatrie
Chirurgie Générale

Ophtalmologie
Anatomie Pathologique
Oto-Rhino-Laryngologie
Gastro-Entérologie
Anesthésie Réanimation
Stomatologie et Chirurgie Maxillo-faciale
Neurologie
Traumatologie Orthopédie
Anatomie Pathologique
Radiologie
Gynécologie Obstétrique
Pédiatrie
Cardiologie
Chirurgie Générale
Pédiatrie



Pr. KHARMAZ Mohamed
Pr. MOUGHIL Said
Pr. OUBAAZ Abdelbarre*
Pr. TARIB Abdelilah*
Pr. TIJAMI Fouad
Pr. ZARZUR Jamila

Traumatologie Orthopédie
Chirurgie Cardio-Vasculaire
Ophtalmologie
Pharmacie Clinique
Chirurgie Générale
Cardiologie

Janvier 2005

Pr. ABBASSI Abdellah
Pr. AL KANDRY Sif Eddine*
Pr. ALLALI Fadoua
Pr. AMAZOUZI Abdellah
Pr. AZIZ Nouredine*
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Pr. BARKAT Amina
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Pr. LYAGOUBI Mohammed
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Pr. SBIHI Souad
Pr. ZERAIDI Najia

Chirurgie Réparatrice et Plastique
Chirurgie Générale
Rhumatologie
Ophtalmologie
Radiologie
Rhumatologie
Pédiatrie
Cardiologie
Ophtalmologie
Biophysique
Microbiologie
Cardiologie (*mise en disponibilité*)
Pédiatrie
Radiologie
Chirurgie Cardio-vasculaire
Parasitologie
Rhumatologie
Gynécologie Obstétrique
Histo-Embryologie Cytogénétique
Gynécologie Obstétrique



Décembre 2005

Pr. CHANI Mohamed

Anesthésie Réanimation

Avril 2006

Pr. ACHEMLAL Lahsen*
Pr. AKJOUJ Said*
Pr. BELMEKKI Abdelkader*
Pr. BENCHEIKH Razika
Pr. BIYI Abdelhamid*
Pr. BOUHAFS Mohamed El Amine

Rhumatologie
Radiologie
Hématologie
O.R.L
Biophysique
Chirurgie - Pédiatrique

Pr. BOULAHYA Abdellatif*
Pr. CHENGUETI ANSARI Anas
Pr. DOGHMI Nawal
Pr. FELLAT Ibtiham
Pr. FAROUDY Mamoun
Pr. HARMOUCHE Hicham
Pr. HANAFI Sidi Mohamed*
Pr. IDRIS LAHLOU Amine*
Pr. JROUNDI Laila
Pr. KARMOUNI Tariq
Pr. KILI Amina
Pr. KISRA Hassan
Pr. KISRA Mounir
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Pr. SAFI Soumaya*
Pr. SEKKAT Fatima Zahra
Pr. SOUALHI Mouna
Pr. TELLAL Saida*
Pr. ZAHRAOUI Rachida

Octobre 2007

Pr. ABIDI Khalid
Pr. ACHACHI Leila
Pr. ACHOUR Abdessamad*
Pr. AIT HOUSSA Mahdi*
Pr. AMHAJJI Larbi*
Pr. AOUI Sarra
Pr. BAITE Abdelouahed*
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Pr. BENZIANE Hamid*
Pr. BOUTIMZINE Nourdine
Pr. CHARKAOUI Naoual*
Pr. EHIRCHIOU Abdelkader*
Pr. ELABSI Mohamed
Pr. EL MOUSSAOUI Rachid
Pr. EL OMARI Fatima
Pr. GHARIB Noureddine

Chirurgie Cardio – Vasculaire
Gynécologie Obstétrique
Cardiologie
Cardiologie
Anesthésie Réanimation
Médecine Interne
Anesthésie Réanimation
Microbiologie
Radiologie
Urologie
Pédiatrie
Psychiatrie
Chirurgie – Pédiatrique
Pharmacie Galénique
Parasitologie
Radiothérapie
Psychiatrie
Endocrinologie
Psychiatrie
Pneumo – Phtisiologie
Biochimie
Pneumo – Phtisiologie

Réanimation médicale
Pneumo phtisiologie
Chirurgie générale
Chirurgie cardio vasculaire
Traumatologie orthopédie
Parasitologie
Anesthésie réanimation **Directeur ERSM**
Biochimie-chimie
Pharmacie clinique
Ophtalmologie
Pharmacie galénique
Chirurgie générale
Chirurgie générale
Anesthésie réanimation
Psychiatrie
Chirurgie plastique et réparatrice



Pr. HADADI Khalid*
Pr. ICHOU Mohamed*
Pr. ISMAILI Nadia
Pr. KEBDANI Tayeb
Pr. LALAOUI SALIM Jaafar*
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Pr. MRANI Saad*
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Pr. TACHFOUTI Samira
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Pr. TANANE Mansour*
Pr. Tligui Houssain
Pr. TOUATI Zakia
Décembre 2007
Pr. DOUHAL ABDERRAHMAN

Décembre 2008

Pr ZOUBIR Mohamed*
Pr TAHIRI My El Hassan*
Mars 2009
Pr. ABOUZAHIR Ali*
Pr. AGDR Aomar*
Pr. AIT ALI Abdelmounaim*
Pr. AIT BENHADDOU El hachmia
Pr. AKHADDAR Ali*
Pr. ALLALI Nazik
Pr. AMINE Bouchra

Radiothérapie
Oncologie médicale
Dermatologie
Radiothérapie
Anesthésie réanimation
Microbiologie
Réanimation médicale
Radiologie
Pneumo phtisiologie
Hématologique
Médecine préventive santé publique et hygiène
Virologie
Biochimie-chimie
Médecine interne
Radiologie
Microbiologie
Microbiologie
Radiothérapie
Chirurgie vasculaire périphérique
Ophtalmologie
Chirurgie générale
Traumatologie orthopédie
Parasitologie
Cardiologie

Ophtalmologie



Anesthésie Réanimation
Chirurgie Générale

Médecine interne
Pédiatre
Chirurgie Générale
Neurologie
Neuro-chirurgie
Radiologie
Rhumatologie

Pr. ARKHA Yassir
Pr. BELYAMANI Lahcen*
Pr. BJIJOU Younes
Pr. BOUHSAIN Sanae*
Pr. BOUI Mohammed*
Pr. BOUNAIM Ahmed*
Pr. BOUSSOUGA Mostapha*
Pr. CHAKOUR Mohammed *
Pr. CHTATA Hassan Toufik*
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Pr. EL MALKI Hadj Omar
Pr. EL OUENNASS Mostapha*
Pr. ENNIBI Khalid*
Pr. FATHI Khalid
Pr. HASSIKOU Hasna *
Pr. KABBAJ Nawal
Pr. KABIRI Meryem
Pr. KARBOUBI Lamya
Pr. L'KASSIMI Hachemi*
Pr. LAMSAOURI Jamal*
Pr. MARMADE Lahcen
Pr. MESKINI Toufik
Pr. MESSAOUDI Nezha *
Pr. MSSROURI Rahal
Pr. NASSAR Ittimade
Pr. OUKERRAJ Latifa
Pr. RHORFI Ismail Abderrahmani *

PROFESSEURS AGREGES :

Octobre 2010

Pr. ALILOU Mustapha
Pr. AMEZIANE Taoufiq*
Pr. BELAGUID Abdelaziz
Pr. BOUAITY Brahim*
Pr. CHADLI Mariama*
Pr. CHEMSI Mohamed*
Pr. DAMI Abdellah*
Pr. DARBI Abdellatif*
Pr. DENDANE Mohammed Anouar

Neuro-chirurgie
Anesthésie Réanimation
Anatomie
Biochimie-chimie
Dermatologie
Chirurgie Générale
Traumatologie orthopédique
Hématologie biologique
Chirurgie vasculaire périphérique
Hématologie clinique
Chirurgie Générale
Microbiologie
Médecine interne
Gynécologie obstétrique
Rhumatologie
Gastro-entérologie
Pédiatrie
Pédiatrie
Microbiologie **Directeur Hôpital My Ismail**
Chimie Thérapeutique
Chirurgie Cardio-vasculaire
Pédiatrie
Hématologie biologique
Chirurgie Générale
Radiologie
Cardiologie
Pneumo-phtisiologie



Anesthésie réanimation
Médecine interne
Physiologie
ORL
Microbiologie
Médecine aéronautique
Biochimie chimie
Radiologie
Chirurgie pédiatrique

Pr. EL HAFIDI Naima
Pr. EL KHARRAS Abdennasser*
Pr. EL MAZOUZ Samir
Pr. EL SAYEGH Hachem
Pr. ERRABIH Ikram
Pr. LAMALMI Najat
Pr. MOSADIK Ahlam
Pr. MOUJAHID Mountassir*
Pr. NAZIH Mouna*
Pr. ZOUAIDIA Fouad

Pédiatrie
Radiologie
Chirurgie plastique et réparatrice
Urologie
Gastro entérologie
Anatomie pathologique
Anesthésie Réanimation
Chirurgie générale
Hématologie
Anatomie pathologique

Mai 2012

Pr. AMRANI Abdelouahed
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Dedications



To my parents:

To my father

I dedicate this work to my beloved father, who has been a source of encouragement and inspiration to me throughout my life, thank you for providing me help, and also for the myriad of ways in which , you have actively supported me in my determination to find and realize my potential, and to make this contribution to our world. Thank you, For showing faith in me and giving me the liberty to choose what I desired. I salute you for the selfless love, care, pain, and sacrifice you did to shape my life. Although you hardly understood what I researched on, you were willing to support any decision I made. I would never be able to pay back the love and affection showered upon by you. who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

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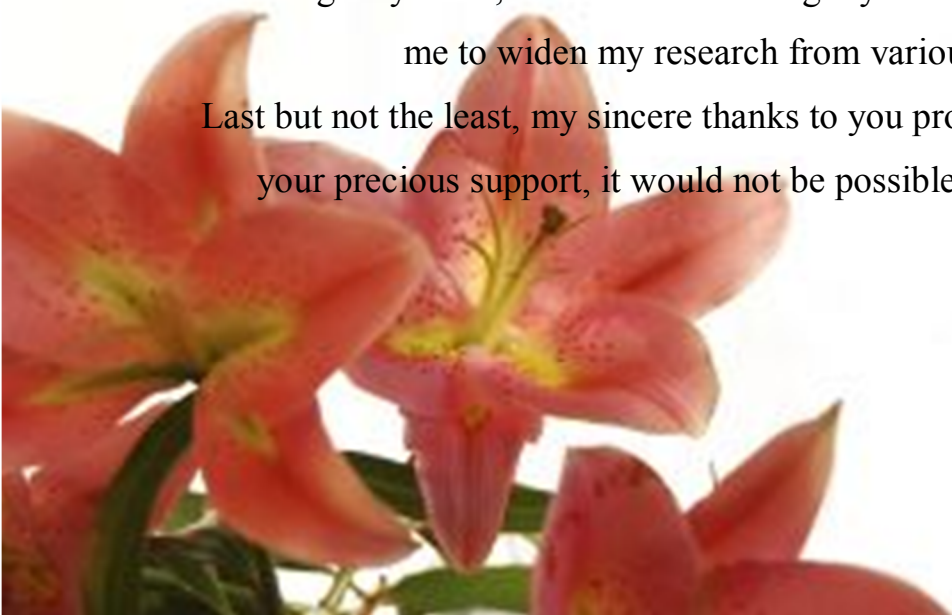
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SUMMARY

	INTRODUCTION.....	1
	GENERAL INFORMATION AND REVIEW.....	4
I-	ENGLISH LANGUAGE	5
II-	ANATOMY REVIEW.....	6
A.	Base of the skull.....	6
1.	Anterior fossa.....	9
2.	Middle fossa.....	9
B.	Structures of the skull base.....	11
1.	Anterior cranial fossa.....	11
2.	Middle cranial fossa.....	11
C.	Meninges.....	13
1.	Dura mater.....	13
2.	Arachnoid mater.....	14
3.	Pia mate.....	14
III-	CLASSIFICATION OF ANTERIOR AND MIDDLE SKULL BASI	15
	MENINGIOMAS (based on literature and our findings)	
A.	CUSHING and EINSHENHARDT classification.....	15
B.	JAN's classification.....	15
C.	PHILIPPON J	15
D.	AL MEFTY's classification.....	16
E.	SCHMIDEK's classification.....	16
F.	HALFADL classification.....	17
G.	CLASSIFICATION USED IN THIS SERIES.....	17
	MATERIAL AND METHODS.....	19
I.	Study period.....	20
II.	Inclusion criteria.....	20

III.	Methods.....	20
	RESULTS.....	22
I.	Epidemiology.....	23
A.	Frequency.....	23
B.	Age.....	23
C.	Gender.....	24
II.	Clinical results.....	26
A.	Past history	26
B.	Diagnosis delay.....	27
C.	Clinical presentation.....	28
1.	Functional signs.....	28
2.	Physical examination.....	28
2.1.	GCS	28
2.2.	Motor deficit.....	29
2.3.	Aphasia and memory disorders.....	29
2.4.	Nerve deficit.....	29
2.4.1.	Optic nerve.....	29
2.5.1.	Other nerve damage.....	32
2.6.	Visual field.....	33
2.7.	Fundus results.....	33
3.	Clinical presentation based on meningiomas location.....	34
III.	Imaging results.....	37
A.	Neuroradiology features of meningiomas in our series.....	37
1.	Plain X rays.....	37
2.	CT head scan.....	37
3.	MRI.....	38

4.	MR spectroscopy	41
5.	Cerebral angiography.....	41
B.	NeuroRadiologic results by location.....	41
IV.	Laboratory investigation.....	44
V.	Treatment.....	44
A.	Surgical management	44
1.	Preoperative management	44
2.	Surgical technique.....	45
2.1.	Position.....	45
2.2.	Surgical approach.....	45
2.2.1.	Anterior fossa n=16	45
2.2.2.	Middle fossa:(n=84.....	46
2.3.	Macroscopic aspect.....	49
2.4.	Resection.....	50
2.5.	Surgery duration.....	51
2.6.	Intraoperative incidents.....	51
3.	Postoperative care.....	52
3.1.	Corticotherapy.....	52
3.2.	Antibiotherapy.....	52
3.3.	Anticonvulsants.....	52
3.4.	Anticoagulant treatment.....	52
3.4.1	Preventive anticoagulant therapy.....	52
3.4.2	Curative anticoagulant therapy.....	52
3.5.	Insulin therapy.....	52
3.6.	Analgesic drugs	52
B.	Radiosurgery.....	53

1.	Indications in our series.....	53
2.	Surgical technique.....	53
2.1.	Volume.....	53
2.2.	Dose.....	53
3.	Intraoperative incidents.....	53
4.	Postoperative care.....	53
5.	Results of treatment.....	53
C.	Radiotherapy and chemotherapy.....	53
VI.	Pathology.....	54
VII.	Outcome and prognosis.....	55
A.	Short term result.....	55
1.	Duration of ICU Stay	55
2.	Neurological outcome.....	55
3.	Vision outcome.....	56
4.	Postoperative mortality.....	57
4.1.	Age, gender, past history.....	59
4.2.	Preoperative neurological status.....	59
4.3.	Location, size of tumor, and perilesional edema.....	59
4.4.	Surgical approach, resection, pathology.....	60
4.5.	Duration surgery.....	60
5.	Others.....	62
B.	Long term results.....	62
1.	Follow up results.....	63
2.	Recurrence.....	64
2.1.	Age and gender.....	65
2.2.	Recurrence delay.....	65

2.3.	Location	65
2.4.	Resection	66
2.5.	Histopathology:	66
2.6.	Management.....	67
VIII.	Prognosis.....	70
	DISCUSSION.....	71
I-	HISTORY.....	71
A.	Before the Twentieth Century.....	72
B.	The early twentieth century : before Cushing.....	73
C.	Cushing's Contribution.....	73
D.	Mid- to Late-Twentieth Century.....	74
II-	EPIDEMIOLOGY.....	74
A.	Risk factors.....	74
1.	Ionizing Radiation.....	74
2.	Hormones.....	75
3.	Association with Breast Cancer.....	77
4.	Head Trauma.....	77
5.	Cell Phone Use.....	78
6.	Industry/Occupation/Diet/Allergy.....	78
7.	Family History of Meningioma.....	78
8.	Genetic Polymorphisms.....	79
8.1.	Chromosome 22 and the NF2 Gene.....	79
8.2.	DAL-1.....	79
B.	Frequency.....	82
C.	Age and gender.....	82
III-	Clinical presentation.....	83

A.	Anterior fossa.....	83
B.	Middle fossa.....	87
IV-	Neuroradiological evaluation.....	105
A.	CT scan.....	105
B.	MRI.....	110
C.	Angiography.....	114
V-	Differential diagnosis.....	115
A.	Hyperostosis.....	115
B.	Bone destruction.....	117
C.	Enlarged vascular markings.....	117
D.	Tumoral calcification.....	117
E.	By location.....	118
VI-	Anterior and middle skull base surgery.....	120
A.	Preoperative preparation.....	120
1.	Drugs.....	120
2.	Preoperative embolization.....	122
B.	Surgical management.....	123
1.	Position.....	123
2.	Preoperative management.....	123
3.	Neuronavigation.....	123
4.	Surgical approach and technique.....	124
4.1.	Anterior fossa.....	125
4.2.	Middle fossa.....	128
4.2.1.	Suprasellar meningioma.....	128
4.2.2.	Laterosellar meningiomas.....	133
4.2.3.	Sphenoid wings meningiomas.....	136

4.2.3.1.	Lesser sphenoid wing.....	136
4.2.3.2.	Greater sphenoid wing.....	140
4.2.4.	Sphenoorbital meningioma.....	140
5.	Excision quality.....	144
6.	Application of endoscopy in the management of anterior and skull base meningiomas.....	144
VII-	Pathology.....	146
A.	Grades.....	147
B.	Immunohistochemistry.....	150
C.	Differential Diagnosis.....	151
VIII-	Outcome.....	152
A.	Perioperative incidents.....	152
B.	Morbidity.....	153
1.	Olfactory groove/orbital roof.....	155
2.	Suprasellar meningiomas.....	155
3.	Cavernous sinus.....	156
4.	Posterior clinoid process.....	157
5.	Lateral and middle sphenoid wing meningiomas.....	157
6.	Anterior clinoid process.....	158
7.	Sphenoorbital (En plaque) meningiomas.....	159
C.	Mortality.....	160
1.	Olfactory groove/roof of orbit meningiomas.....	160
2.	Suprasellar meningiomas.....	161
3.	Cavernous sinus meningiomas.....	162
4.	Posterior clinoid process meningiomas.....	162
5.	Lateral and middle sphenoid wing meningiomas.....	163

6.	Anterior clinoid process meningiomas.....	163
7.	Greater sphenoid wing meningiomas.....	163
8.	Sphenoorbital (En plaque) meningioma.....	164
D.	Recurrence.....	164
1.	Olfactory groove/roof of orbit meningiomas.....	165
2.	Suprasellar meningiomas.....	166
3.	Cavernous sinus meningiomas.....	166
4.	Lateral and middle sphenoid wing meningiomas.....	167
5.	Anterior clinoid process meningiomas.....	167
6.	Sphenoorbital (En plaque) meningiomas.....	168
IX-	Prognostic factors related to the patient.....	169
A.	Prognostic.....	170
1.	Age.....	170
2.	Gender.....	171
3.	Patient's history.....	171
4.	Preoperative status.....	171
B.	Tumor features.....	172
1.	Locations.....	172
2.	Size.....	173
3.	Perilesional edema.....	173
4.	WHO Grade.....	173
C.	Surgery features.....	174
1.	Grade of excision.....	175
2.	Operative duration.....	175
3.	Surgical experience and technique.....	176
X-	radiosurgery.....	176

A.	Indications for radiosurgery.....	177
B.	Morbidity of Radiosurgery	177
XI-	Radiotherapy.....	178
A.	Indications for radiotherapy.....	178
B.	Limitations and morbidity of Radiotherapy.....	179
XII-	Chemotherapy.....	181
A.	Biochemotherapy.....	181
B.	Targeted Therapy.....	182
C.	Hormonotherapy.....	184
	SUMMARY.....	186
	INVESTIGATION.....	192
	BIBLIOGRAPHY.....	196

ILLUSTRATIONS

Figure 1 bones of the skull base	6
Figure 2 midsagittal section of the skull bas.....	7
Figure 3 interior of the skull base.....	8
Figure 4 cranial nerves of the skull base	12
Figure 5 neurovascular strucutres of skull base	13
Figure 6 Dural reflections and venous sinuses. The midbrain occupies the tentorial notch.....	14
Figure 7 Distribution by years	23
Figure 8 cases distribution by age	24
Figure 9 cases distribution by gender	24
Figure 10 distribution by age and gender	25
Figure 11 patient past history.....	27
Figure 12 Both eyes impairment	30
Figure 13 OLFACTORY NERVE	31
Figure 14 nerve damage Summary.....	32
Figure 15 summary of clinical presentation in our series.....	34
Figure 16 mean size by location.....	39
Figure 17 MRI planum sphenoidale meningioma.....	40
Figure 18 MRI T1 external sphenoidal wing meningioma.....	40
Figure 19 Our intraoperative photographs of an external sphenoid wing meningioma surgery	48
Figure 21 simpson grade.....	50
Figure 22 histopathology	55
Figure 23 Gender and mortality	58
Figure 24 past medical history: Diabetes, Dyslipedimia, HBP and morality	58
Figure 25 Karnofsky scale and mortality.....	59
Figure 26 gender and recurrence.....	65

Figure 27 location and recurrence	66
Figure 28 WHO grade and recurrence.....	66
Figure 29 Class II score	68
Figure 30 The genetic alterations underlying meningioma formation and progression.	81
Figure 31 Illustration of the OGMS in the bony base of the skull.....	84
Figure 32 Projection of olfactory groove meningioma (in blue)	84
Figure 33 Schematic diagram demonstrating TSMs.....	89
Figure 34 sites of implantation of nodular types of sphenoid wing meningiomas.....	97
Figure 35 Bony anatomy of the anterior clinoid process region and distribution of ACPMS	98
Figure 36 Sagittal CT at bone window settings identifies hyperostosis of the anterior skull base (arrows).....	109
Figure 37 dural tail in meningioma (arrow)	112
Figure 38 Sagittal post contrast T1-weighted MRI reveals a large tumor extending back into the sella turcica.....	113
Figure 39 selecting patients with meningioma for POE.....	122
Figure 40 illustration showing approaches for, anterior and middle skull base MENINGIOMAS	124
Figure 41 Devascularization steps of meningioma	125
FIGURE 42 FRONTO TEMPORAL APPROACH	129
Figure 43: suprasellar meningioma	130
Figure 44 suprasellar meningioma.	131
Figure 45 Illustration showing the superior interhemispheric approach.....	132
Figure 46 frontotemporal approach through a subcoronal incision	137
Figure 47 orbitocranial zygomatic approach	142
Figure 48 diagram showing the different parameters affecting the outcome after surgery for meningiomas	175



Figure 49 radiotherapy plan for a large benign meningioma in the right CS 179

Figure 50 Simplified scheme of cell signaling pathways involved in meningioma pathogenesis
..... 183

.....

TABLES

.....

TABLE 1 CUSHING AND EINSHENHARDT CLASSIFICATION	15
Table 2 HALFADEL classification.....	17
Table 3 past history of our series	26
Table 4 diagnosis delay	27
Table 5 The glasgow score of our series.....	29
Table 6 nerve damage in our series.....	32
Table 7 visual field in our series	33
Table 8 Fundus results.....	33
Table 9 clinical presentation by location.....	35
Table 10 physical examination by location	36
Table 11 Summary of CT scan features	38
Table 12 MRI features in our series	38
Table 13 Distrubution of the mean size by location.....	39
Table 14 Angiographic signs in our series.....	41
Table 15 distribution of patients by location	41
Table 16 size of meningioma by location.....	42
Table 17 neurodariologic features by location.....	43
Table 18 Asa classification	44
Table 19 Surgical approches in our series	47
Table 20 masroscopic color described in the operative report.....	49
Table 21 Simpson score.....	50
Table 22 resection by location	51
Table 23 intraoperative incidents	51
Table 24 HISTOPATHOLOGY RESULTS IN OUR SERIES.....	54
Table 25 duration stay of patients in ICU.....	55
Table 26 summary of morbidity and postoperative cranial nerve deficit.....	56

Table 27 vision outcome.....	56
Table 28 age and mortality	57
Table 29 location and mortality	59
Table 30 surgical approach and mortality.....	60
Table 31 simpson grade and mortality	60
Table 32 pathology and mortality	60
Table 33 Mortality in our series	61
Table 34 postoperative complications in our series	62
Table 35 karnofsky scale	63
Table 36 encountered circumstances in recurrence meningiomas.....	64
Table 37 patients with recurrence meningiomas in our series.....	64
Table 38 location and recurrence	65
Table 39 resection and recurrence.....	66
Table 40 Summary of scoring.....	67
Table 41 prognosis citation.....	68
Table 42 anterior and middle skull base meningiomas prognosis	69
Table 43 skull base meningiomas reported in literature.....	82
Table 44 Clinical Features of OGMs Reported in Literature	86
Table 45 decreased vision on both OGMs and PSMs in our series	88
Table 46 Clinical features of TSMs reported in literature.....	90
Table 47 Three types of diaphragma sellae meningiomas.....	91
Table 48 Cranial nerves deficit % reported in literature	93
Table 49 symptoms of cavernous sinus pathology in literature.....	94
Table 50 PCP meningiomas features in literature.....	95
Table 51 Median size of inner and middle third meningiomas.....	100

Table 52 symptoms of the SWMs in a serie of 56 patients at Department of Neurological Surgery, California.	101
Table 53 advantages and disadvantages of Preoperative embolization	122
Table 54 Advantages and Disadvantages of the PT and SF approach	127
Table 55 disadvantages of different approaches in PCPS	135
Table 56 Simpson Grading Scale for Removal of Meningiomas	144
Table 57 Who classification of meningiomas.....	146
Table 58 Olfactory Groove Meningiomas and outcome	154
Table 59 Improvement outcome of OGMs.....	154
Table 60 new cranial nerve deficit in CSMs by authors.....	156
Table 61 Reported cases of PCP meningiomas and their complications	157
Table 62 Anterior Clinoidal Meningioma morbidity	159
Table 63 mortality of Olfactory Groove Meningiomas.....	161
Table 64 TSMs mortality by authors	161
Table 65 Mortality in CSMs reported by authors	162
Table 66 rate of mortality in ACP meingiomas by authors	163
Table 67 recurrence rate in TSMs	166
Table 68 tumor recurrence after surgical resection of CSMs	167
Table 69 Reccurence after Anterior Clinoidal Meningioma Resection	168
Table 70 radiosurgery indications in anterior and middle skull base meningiomas.....	176

ABBREVIATIONS

Anterior and middle skull base meningiomas

- 1.2 DAG: 1,2-diacylglycerol
- ACA: Anterior cerebral arteries;
- ACP :Anterior clinoid process;
- ACPMS: Anterior clinoid process meningiomas
- BF: Bifrontal
- BFO: Bifrontoorbital
- CN: Cranial nerve
- CSMs : Cavernous sinus meningiomas
- ESWMs: External sphenoid wing meningiomas
- FT: Fronto temporal
- GSWMs: greater sphenoid wing meningiomas
- GTR: Gross total resection
- H/A: Headaches
- HBP : High blood pressure
- HH: Homonymous hemianopia,
- HSR: Hôpital des Spécialités Rabat
- IAC: Internal auditory canal (IAC)
- ICA: Internal carotid artery
- IH: Interhemispheric
- IP3: Inositol 1,4,5-trisphosphate
- IR: Ionizing radiation
- LSO: lateral supraorbital
- MDACC, M.D. Anderson Cancer Center.
- MEP: Motor evoked potentials
- MSWMs: Middle sphenoid wing meningiomas
- NA : Not Available

Anterior and middle skull base meningiomas

- NCCT : Non-contrast computer tomography
- OC Optic canal;
- OGMs : Olfactory groove meningiomas
- OZA: Orbitozygomatic approach
- P-com arteries: Posterior communicating arteries
- PCP: Posterior clinoid process
- PCPMs :Posterior clinoid process meningiomas
- PDK1: Phosphoinositide-dependent kinase–1
- PR: progesterone receptors
- PSMs: Planum sphenoidale meningiomas
- Pt: Pterional
- PTBE: peritumoral brain edema
- PTEN: phosphatase and tensin homolog;
- PVD: peripheral vascular disease.
- RBC : Red blood cells
- RDS: radiosurgery
- RNAi: RNA interference;
- RON : Radiation optic neuropathy
- SD : Standard deviation.
- SF: Subfrontal
- SIR: Standardized incidence ratios
- SOF: Superior orbital fissure
- SOMs: Sphenoorbital meningiomas
- SSS: Superior sagittal sinus
- STR: Subtotal resection
- SWOG : Southwest Oncology Group

Anterior and middle skull base meningiomas

- TSMs: Tuberculum sellae meningiomas
- TTP: Time to progression
- VD: Visual deterioration
- Yrs: years

INTRODUCTION

Meningiomas are the most common primary brain and central nervous system tumor that arise from cells of arachnoid granulations. To optimize patient management and surgical outcome, understanding appropriate surgical objectives and technique based on the location and biology of these neoplasms is critical [1].

Skull base meningiomas remain some of the most challenging lesions in neurosurgery, with lower rates of complete resection and higher neurological morbidity compared with convexity tumors [2]. However, advances in “skull base” approaches— with an emphasis on bony removal to shorten the working distance to the pathology [3], brain retraction and neuronavigation have resulted in a paradigm shift in the management of tumors of the cranial base , and has improved rates of total resection and decreased neurovascular injuries and lesions previously considered inoperable have now become resectable with a chance for cure [4].

Because resection of skull base meningiomas is often limited owing, the involvement of critical neurovascular structures, radiosurgery is an appealing treatment option. Within the last decade, radiosurgery has gained increasing importance as an adjunct treatment after incomplete resection and as an alternative treatment to open surgery [5].

Many questions remain unanswered regarding skull base meningioma, and the objective of this study is to compare the epidemiological, clinical, radiological, therapeutical, and histological aspects, the outcome and the prognosis of our series with those of other series based on literature review.

We studied anterior and middle cranial fossa meningiomas together , despite their specific patterns and differences, they have common clinical, anatomical and surgical features.

Visual impairment is the main revealing symptom in both side as the location of optic nerves and chiasm sitting in the middle of this region.

Anterior and middle skull base meningiomas can be surgically approachable via fronto-lateral/pterional craniotomies, the most commonly used approach.

Our attempt is to continue a previous work conducted by the same team in order to highlight prognosis factors.

GENERAL INFORMATION AND REVIEW

I- ENGLISH LANGUAGE

When we are an ambitious medical students , mastering the Universal Language of Science is mandatory.

There are many reasons we should learn this vital language more than ever, but the number one reason is that English is the dominant language in almost all the fields, and it is the language of Scientific Communication. Becoming fluent in English will help us provide better care and support for international patients, and will allow them explore medicine in other countries.

The place this language has taken in medicine cannot be ignored. Whether we are working in our native country or abroad , time has come when we will need to communicate our findings, and interesting cases.

Fortunately, a developing number of English language programs are offered throughout the English-speaking world to meet the needs of aspiring medical professionals. My personal experience is a living proof of how speaking english fluently is a must. Back in 2016, I had the chance to be a trainee in an elective program of neurosurgery at : McGill University, School of medicine. When I first started, communication was one of my biggest challenges, but my interest, curiosity were much bigger. I took the challenge very seriously and gave it my best. I had as much conversations as possible with patients, residents, and professors. I was always invited to courses and seminars during my elective. And I spent hours reading documents and articles in English.

That was my turning point and I made the decision to work on my doctoral thesis in English. I am happy that my dissertation would be the first medical research thesis written and presented in English. Thanks to my advisor Professor Boutarbouch, who welcomed the idea, and found it very interesting, I am really grateful for her precious encouragement. I hope that This thesis will open other doors, and inspire more students to complete their own in English as well.

II- ANATOMY REVIEW: [6]

A. Base of the skull:

The skull base forms the floor of the cranial cavity and separates the brain from other facial structures. This anatomic region is complex and poses surgical challenges for otolaryngologists and neurosurgeons alike. Working knowledge of the normal and variant anatomy of the skull base is essential for the effective surgical treatment of diseases in this region.

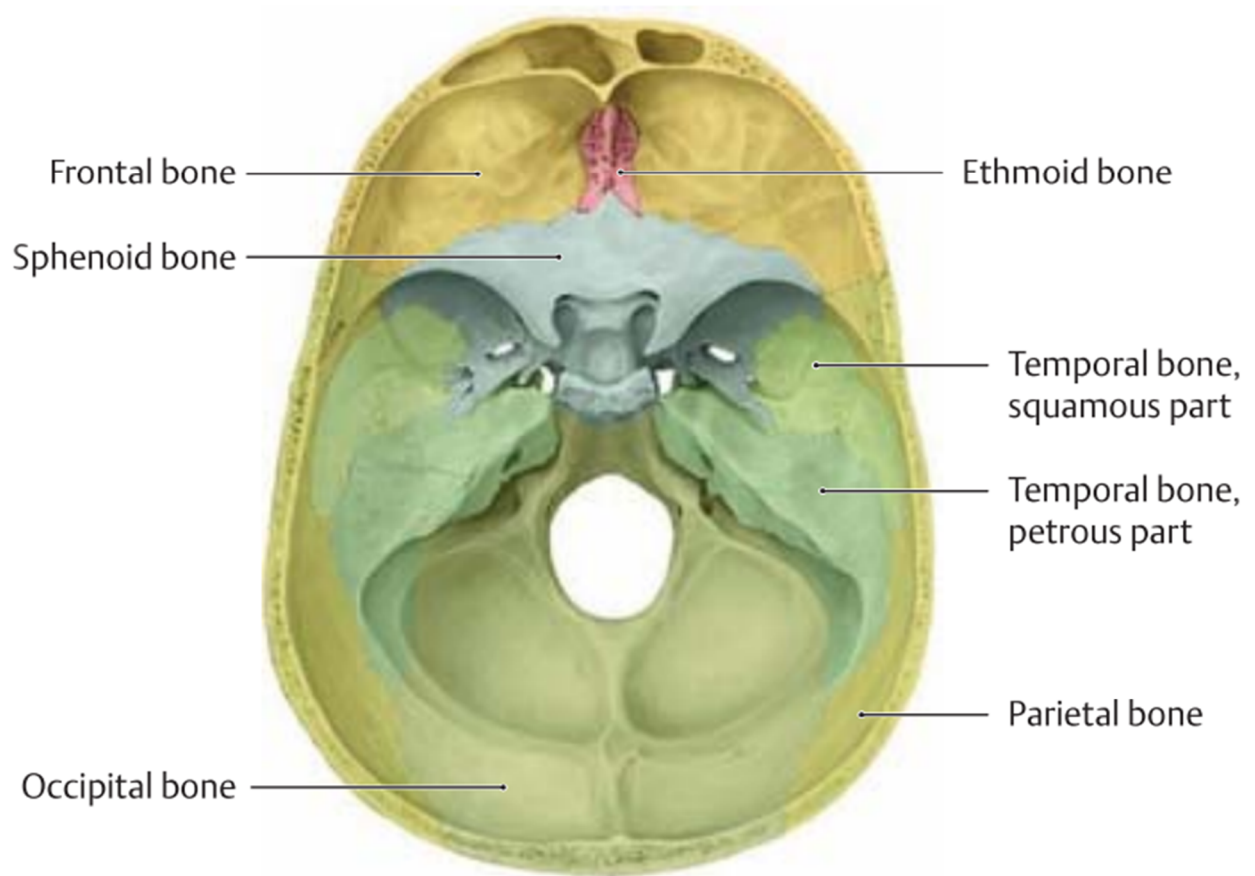


FIGURE 1 BONES OF THE SKULL BASE [6]

Bones of the skull base: different color is used here to highlight the disposition of bones in the base of the skull as seen from within the cranium.

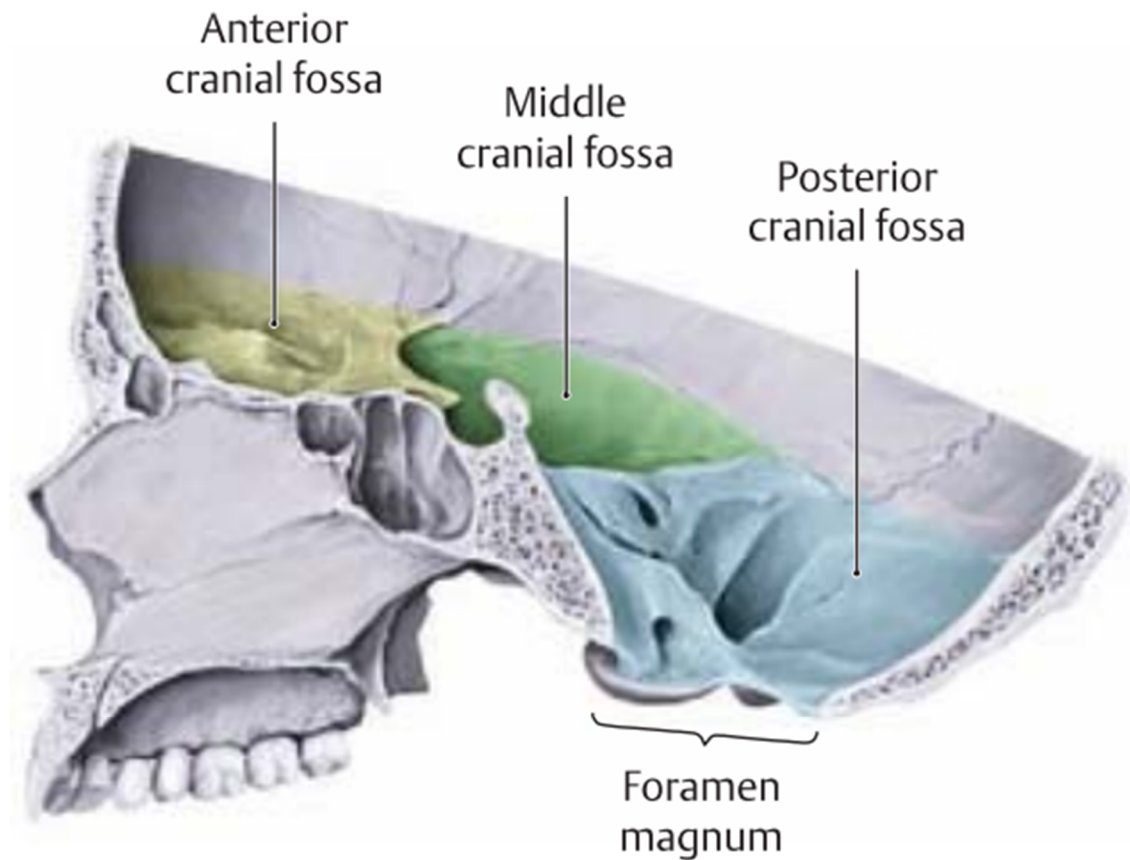


FIGURE 2 MIDSAGITTAL SECTION OF THE SKULL BASE [6]

The interior of the skull base is not flat,-it is deepened to form three successive fossae, the anterior, middle, and posterior cranial fossae. These depressions become progressively deeper in the frontal-to-occipital direction. Forming a terraced arrangement that displaced more clearly in (See Fig 3).The anterior limit of the anterior skull base is the posterior wall of

the frontal sinus. The anterior clinoid processes and the planum sphenoidale, which forms the roof of the sphenoid sinus, mark the posterior limit. The frontal bone forms the lateral boundaries. The frontal bone houses the supraorbital foramina, which, along with the frontal sinuses, form 2 important surgical landmarks during approaches involving the anterior skull base. (See the image below.)

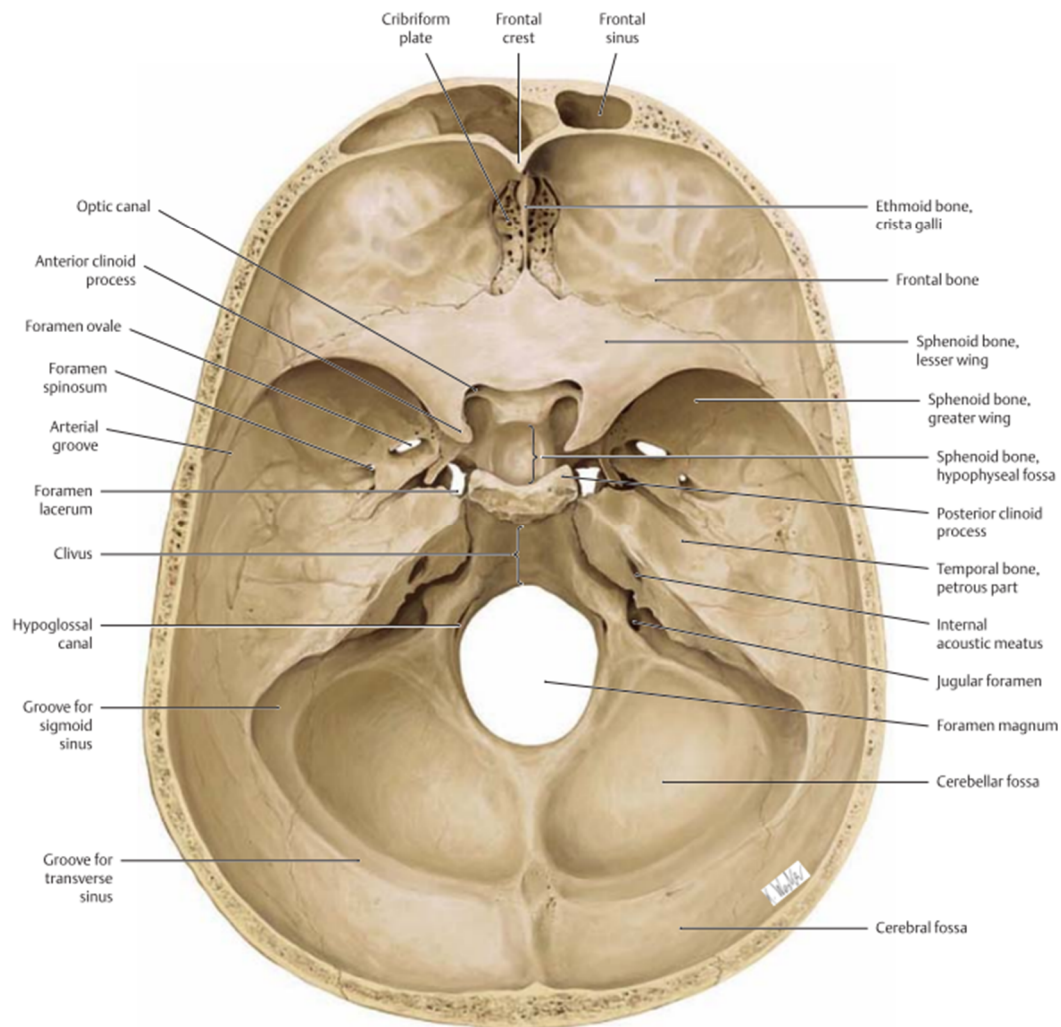


FIGURE 3 INTERIOR OF THE SKULL BASE [6]

1. Anterior fossa:

The greater portion of the anterior floor is convex and grooved by the frontal lobe gyri. This portion of the skull base consists of the orbital portion of the frontal bone. The ethmoid bone forms the central part of the floor, which is the deepest area of the anterior cranial fossa. In the center of this region is the cribriform plate, through which the olfactory tracts pass. The fovea ethmoidalis, or the roof of the ethmoid cavity, continues laterally from the cribriform plate. The cribriform plate may be more than 1 cm lower than the roof of the ethmoid cavity (fovea ethmoidalis), and it is made of extremely thin bone compared with the relatively thick bone of the lateral fovea ethmoidalis. During transethmoidal approaches to the anterior skull base, this relationship is extremely important to remember.

The foramen caecum sits between the frontal crest and the prominent crista galli and is a site of communication between the draining veins of the nasal cavity and the superior sagittal sinus. The crista galli, which projects up centrally between the cerebral hemispheres, serves as the site of attachment for the falx cerebri.

The optic chiasm, or chiasmatic sulcus, sits slightly posteriorly in the midline. The anterior clinoid processes form the posterolateral segment and help form the roof of the optic canal. In the medial aspect, the lesser wing of the sphenoid forms the anterior clinoid process, an important landmark for the optic nerve and supracavernous internal carotid artery (ICA). The major structures in this area are the olfactory bulb and tract. The olfactory bulb lies along the medial edge of the frontal orbital plate and connects with the olfactory tract, which courses above the cribriform plate and planum sphenoidale.

2. Middle fossa:

The greater wing of the sphenoid helps form the anterior limit of the middle skull base. The posterior limit is the clivus, which is formed from the sphenoid and occipital bones. The greater wing of the sphenoid forms the lateral limit as it extends laterally and upward from the

sphenoid body to meet the squamous portion of the temporal bone and the anteroinferior portion of the parietal bone. The greater wing of the sphenoid forms the anterior floor of the fossa. The anterior aspect of the petrous temporal bone forms the posterior floor of the middle cranial fossa.

The body of the sphenoid makes up the central portion of the middle fossa and houses the sella turcica. The sella turcica can be found between the anterior and posterior clinoid processes and is composed of 3 sections. The tuberculum sellae is an olive-shaped swelling and sits on the anterior slope between the chiasmal sulcus and the sella turcica. The hypophyseal or pituitary fossa lies immediately posterior to the tuberculum sellae. The dorsum sellae is the furthest posterior. In this region lies the sigmoid groove for the ICA as it traverses the petrous apex through the cavernous sinus.

The floor and the lateral walls are grooved for the middle meningeal artery, which courses anterolaterally from the foramen spinosum and which divides into frontal and parietal branches. The former ascends across to the pterion, where it courses posteriorly. The pterion is an *H*-shaped suture, where the frontal bone, the greater wing of the sphenoid bone, the squamous temporal bone, and the parietal bone meet.

The petrous portion of the temporal bone forms the posteromedial limit of the middle cranial fossa. The superior petrosal sinus creates a longitudinal groove in the petrous ridge. The anteromedial petrous tip houses the trigeminal or gasserian ganglion in a region known as Meckel cave. This area is superior to the point at which the ICA enters the cavernous sinus just above the foramen lacerum. Along the superomedial surface of the petrous temporal bone, the roof of the carotid canal is frequently dehiscent, a feature that makes dural elevation risky.

B. Structures of the skull base:

In learning the sites where neurovascular structures pass through the base of the skull, it is helpful initially to note whether these sites are located in the anterior, middle fossa.

The next figures will show the important neurovascular structures of the skull base:

1. Anterior cranial fossa:

-cribriform plate:

- Olfactory fibers : collected to form CN I
- anterior and posterior ethmoidal artery

2. Middle cranial fossa:

-optic canal :

- optic nerve (CN II)
- Ophthalmic artery

-Superior orbital fissure:

- oculomotor nerve (CN III)
- Trochlear nerve (CN IV)
- Ophthalmic nerve (CN V1)
- Abducent nerve (CN VI)

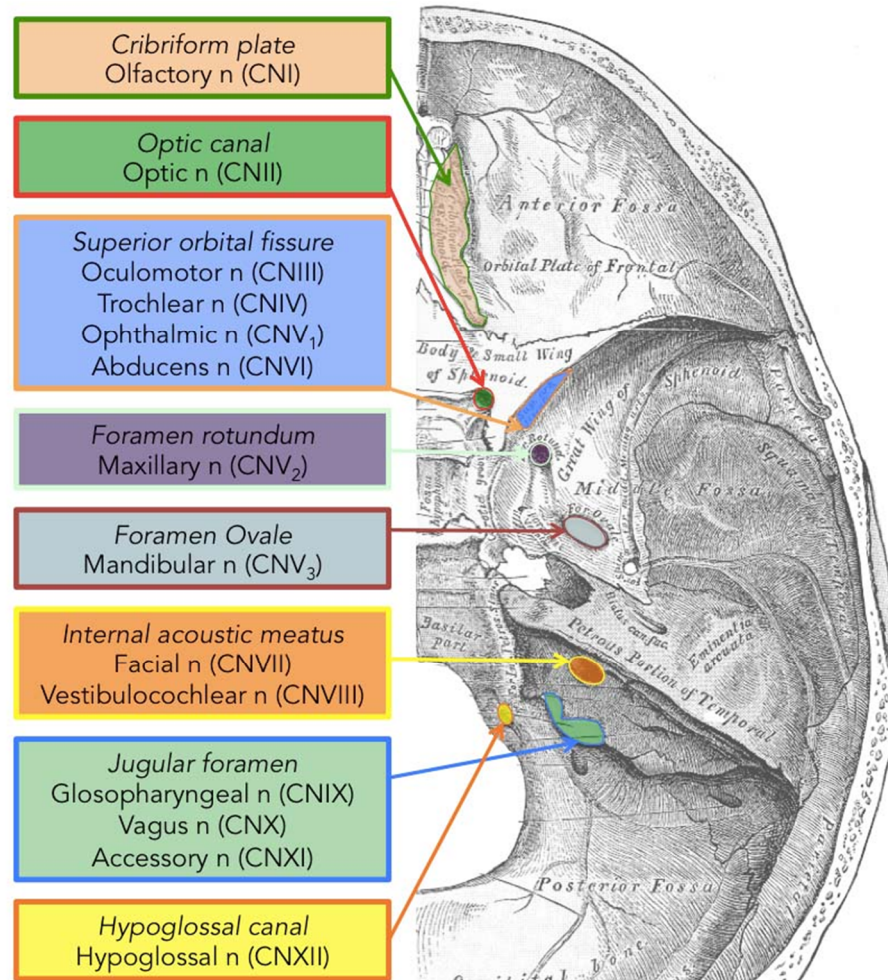


FIGURE 4 CRANIAL NERVES OF THE SKULL BASE [6]

- Superior ophthalmic vein
- Foramen rotundum: maxillary nerve (CN V2)
- Foramen ovale : mandibular nerve (CN V3)
- Foramen spinosum : middle meningeal
- Carotid canal:
 - internal carotid artery
 - Carotid sympathetic plexus

-Hiatus of canal for greater petrosal nerve: greater petrosal nerve

-Hiatus of canal for lesser petrosal nerve: lesser petrosal nerve Superior tympanic artery

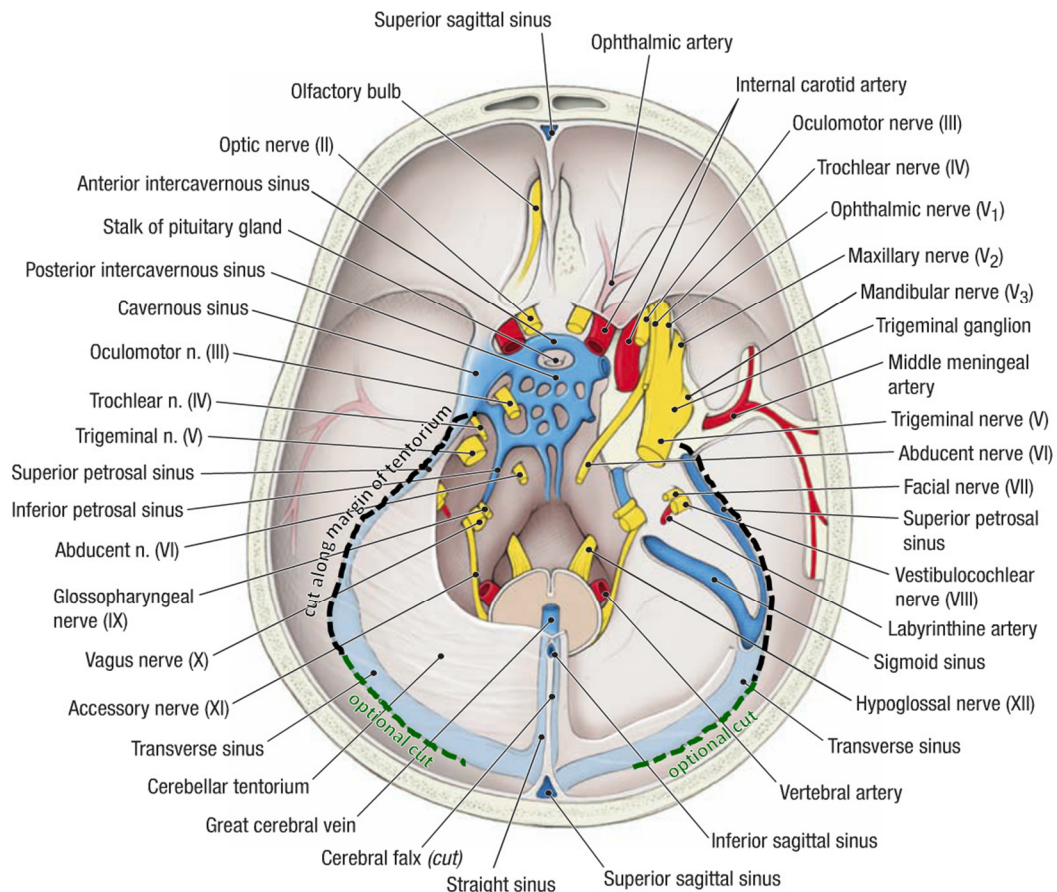


FIGURE 5 NEUROVASCULAR STRUCTURES OF SKULL BASE

B. Meninges:

1. Dura mater

Outermost of the meningeal layers covering the brain; it has 2 layers: periosteal (outer layer) and meningeal (inner layer). It participates in the formation of the dural venous sinuses;

it forms infoldings between portions of the brain that help to support the brain: falx cerebri, falx cerebelli, tentorium cerebelli, diaphragma sellae.

2. Arachnoid mater

Intermediate one of the three layers of meninges, it is a thin membrane which is pressed against the inner surface of the dura mater by cerebrospinal fluid pressure; arachnids are spiders, the space deep to this layer (subarachnoid space) has a spider web-like appearance.

3. Pia mater

Delicate membrane that lies on the surface of the brain and spinal cord, "delicate mother", it is the most delicate of the meninges; this layer faithfully follows all surface contours of the brain and spinal cord; pia mater has 2 specializations: denticulate ligament and filum terminale internum.

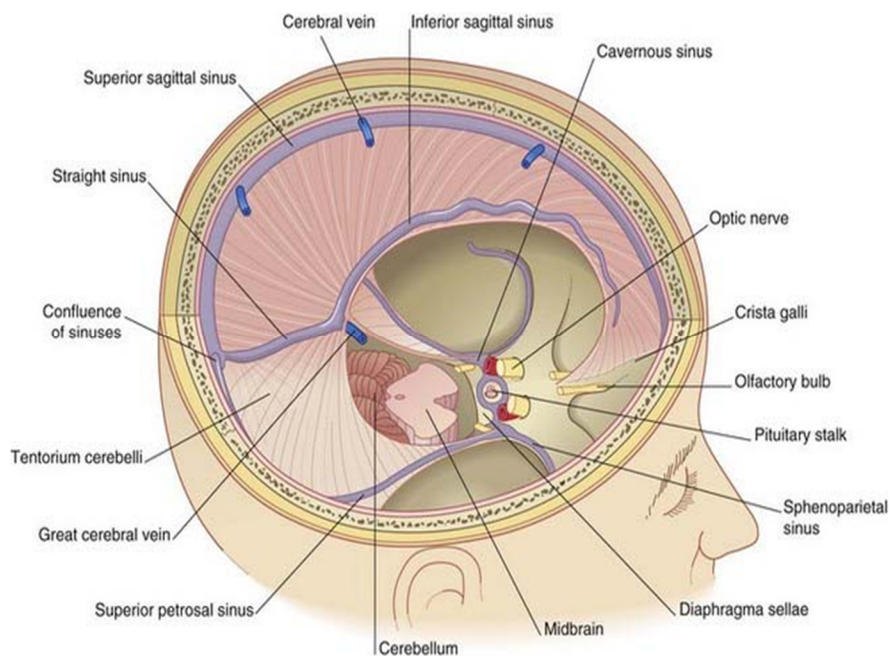


FIGURE 6 DURAL REFLECTIONS AND VENOUS SINUSES. THE MIDBRAIN OCCUPIES THE TENTORIAL NOTCH.

III- CLASSIFICATION OF ANTERIOR AND MIDDLE SKULL BASE MENINGIOMAS (based on literature and our findings):

A. CUSHING and EINSHENHARDT classification: 1938 [7]

Midline skull base	Lateral skull base
1. Olfactory groove 2. Anterior clinoid process 3. Tuberculum sellae 4. Optic sheath 5. Planum sphenoidal 6. Cavernous sinus	1. Lateral /middle sphenoid wing: 2. Orbito sphenoid 3. Orbital roof

TABLE 1 CUSHING AND EINSHENHARDT CLASSIFICATION: 1938 [7]

B. JAN's classification: 1974-1982 [8]

1. Olfactory groove;
2. Inner sphenoidal wing;
3. External sphenoidal wing;
4. Suprasellar.

C. PHILIPPON J : 1971-1980 [9]

1. Olfactory groove;
2. Inner sphenoidal wing;
3. External sphenoidal wing;
4. Planum sphenoidal;

5. Cavernous sinus;
6. Extended basilar topography;
7. Orbital meningioma.

D. AL MEFTY's classification: [10]

- 1.1.Olfactory groove;
- 1.2.Tuberculum sellae meningiomas;
- 1.3.Lateral and middle sphenoid wings meningiomas;
- 1.4.Clinoidal meningiomas;
- 1.5.Cavernous sinus meningiomas;
- 1.6. Sphenoorbital meningioma.

E. SCHMIDEK's classification: [11]

-Sphenoid ridge meningiomas:

- Inner third sphenoid wing
- Middle third or alar meningiomas
- External third or pterional meningiomas

-Olfactory groove

-Suprasellar meningiomas

-Medial sphenoid wing meningiomas

- Superior orbital fissure,
- Cavernous sinus.

F. HALFADEL classification: [12]

Anterior skull base	Suprasellar meningiomas	Laterosellar meningioma	Sphenoid wing	En Plaque
-Ethmoidal meningioma -Orbital roof meningioma	-Planum sphenoidal -Tuberculum sellae -Diaphragm sellae -Optic groove -limbus of sphenoid	-Cavernous sinus -Temporal basal	Inner variety external variety middle variety large variety	

TABLE 2 HALFADEL CLASSIFICATION

G.CLASSIFICATION USED IN THIS SERIES:

For this study, we adopted our own classification using and combining the previous ones.

Anterior fossa:

1. Olfactory groove;
2. Orbital roof.

Middle fossa:

1. Suprasellar meningiomas

- 1.1 Tuberculum sellae.
- 1.2 Diaphragma sellae.
- 1.3 Planum sphenoidale.

2. Laterosellar :

- 2.1 Cavernous sinus.
- 2.2 Posterior clinoid process.

3. Sphenoid wings meningiomas:

3.1. Lesser sphenoidal wing:

- 3.1.1. Inner third sphenoid wing.
- 3.1.2. Middle third or alar meningiomas.
- 3.1.3. External third or pterional meningiomas.

3.2. Greater sphenoidal wing or temporobasal meningioma

4. En plaque : Sphenoorbital meningiomas

MATERIAL AND METHODS

I. Study period

We reviewed the clinical observations of consecutive 100 patients hospitalized for the management of skull base meningioma between January 2003 and January 2016 at the Neurosurgery department of - Hôpital des Spécialités Rabat - CHU Ibn Sina - 13 years.

It is a descriptive study of a retrospective series, consecutive and homogeneous at any age.

II. Inclusion criteria

Inclusion criteria	Exclusion criteria
-All patients who have undergone surgery for anterior or middle skull base fossa meningioma at the neurosurgery department of HSR between January 2003 and 2016.	-Non operated patients -Incomplete data

III. Methods:

Patients data base was conducted, summarized and classified in an Excel Sheet, in which diagrams and descriptive statistics are calculated as well. We used the Excel Function KHI 2 to completely applied a hypostasis test, and to conclude the significance between variable leading to a P-value.

Descriptive statistic : Excel provides a data analysis tool called Descriptive Statistics which produces a summary of the key statistics for a data set (Sum, Mean, Median, Maximum and Minimum variable...etc).

Diagrams and Chart: charts, graphs, or histograms are generated from specified groups of cells in our database and are automatically restructured as the variables are updated.

KHI 2 (Chi Square and test of independence): It is used in hypothesis testing to help figure out if the results are significant or not. A significant result is one where you reject the null hypothesis. In hypothesis testing, there are two questions to asked:

- What do the results tell me about a population?
- What is the strength of those results?

A p-value is a number between 0 and 1, but it's easier to think about them as percentages (i.e. a p-value of 0.05 is 5%). Small p-values (generally under 5%) usually lead you to reject the null hypothesis. This later is a general statement or default position that there is no relationship between two measured phenomena.

RESULTS

I. Epidemiology:

Our series is about 100 patients consecutive treated for anterior or middle skull base fossa meningioma in the department of Neurosurgery - Hôpital des Spécialités Rabat - CHU Ibn Sina - between January 2003 and January 2016.

A. Frequency

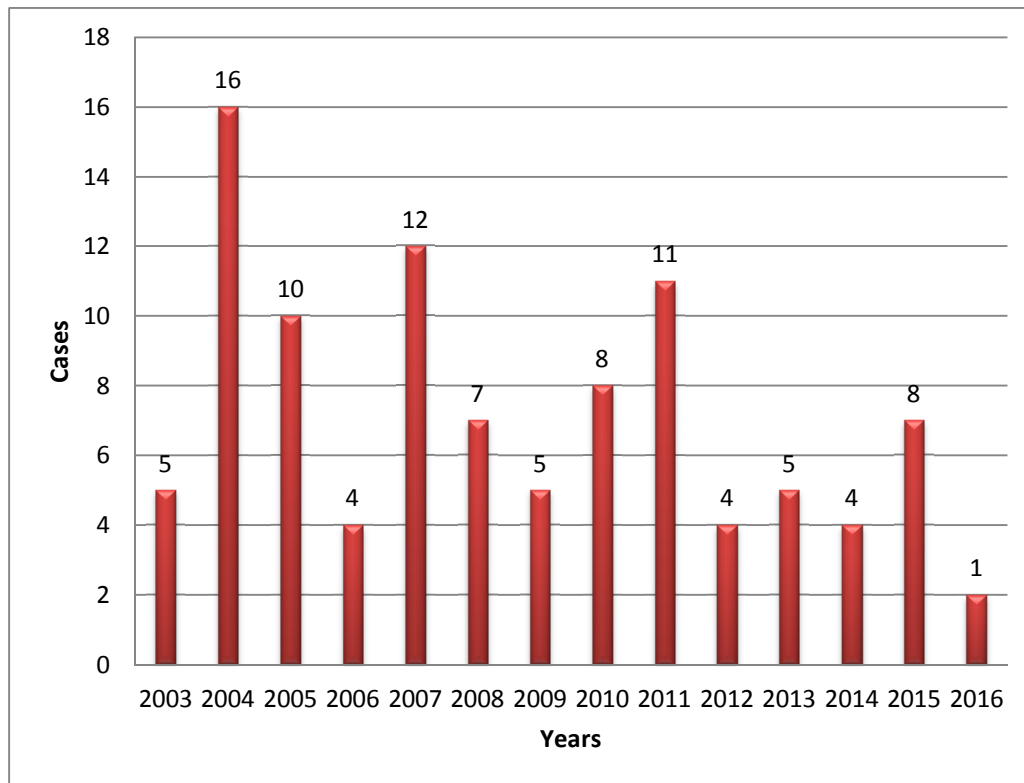


FIGURE 7 DISTRIBUTION BY YEARS

B. Age:

The mean age of our patients is 47,45, ranges from 6 to 71 years. The most affected age group is that between 40 and 49 with a frequency of 34%.

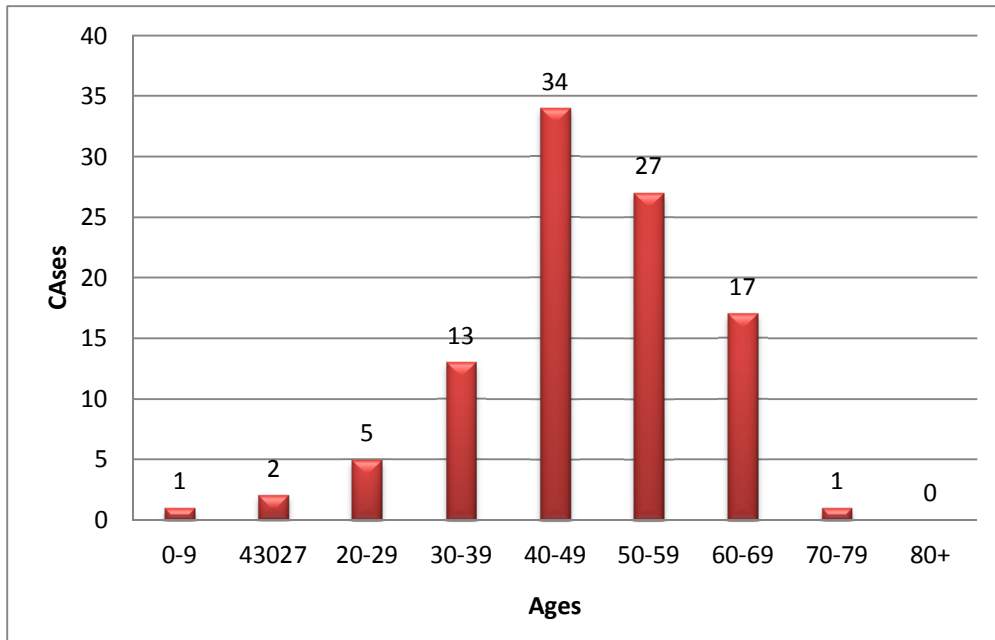


FIGURE 8 CASES DISTRIBUTION BY AGE

C. Gender:

In our series, women represent 70 % of cases (n=70), men account for 30 % of cases (n=30).

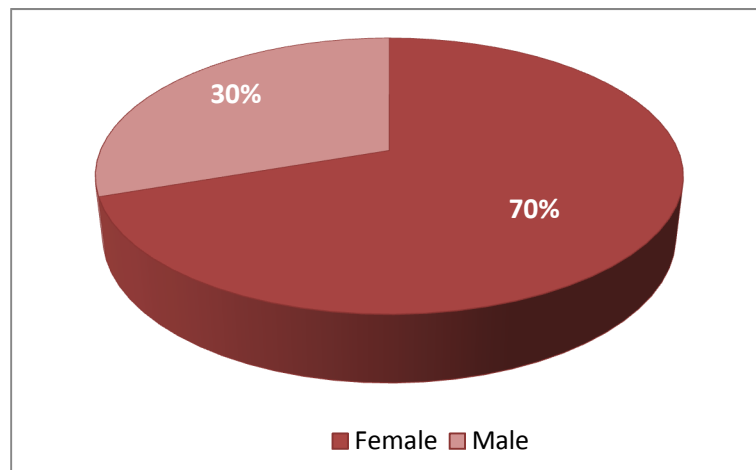


FIGURE 9 CASES DISTRIBUTION BY GENDER

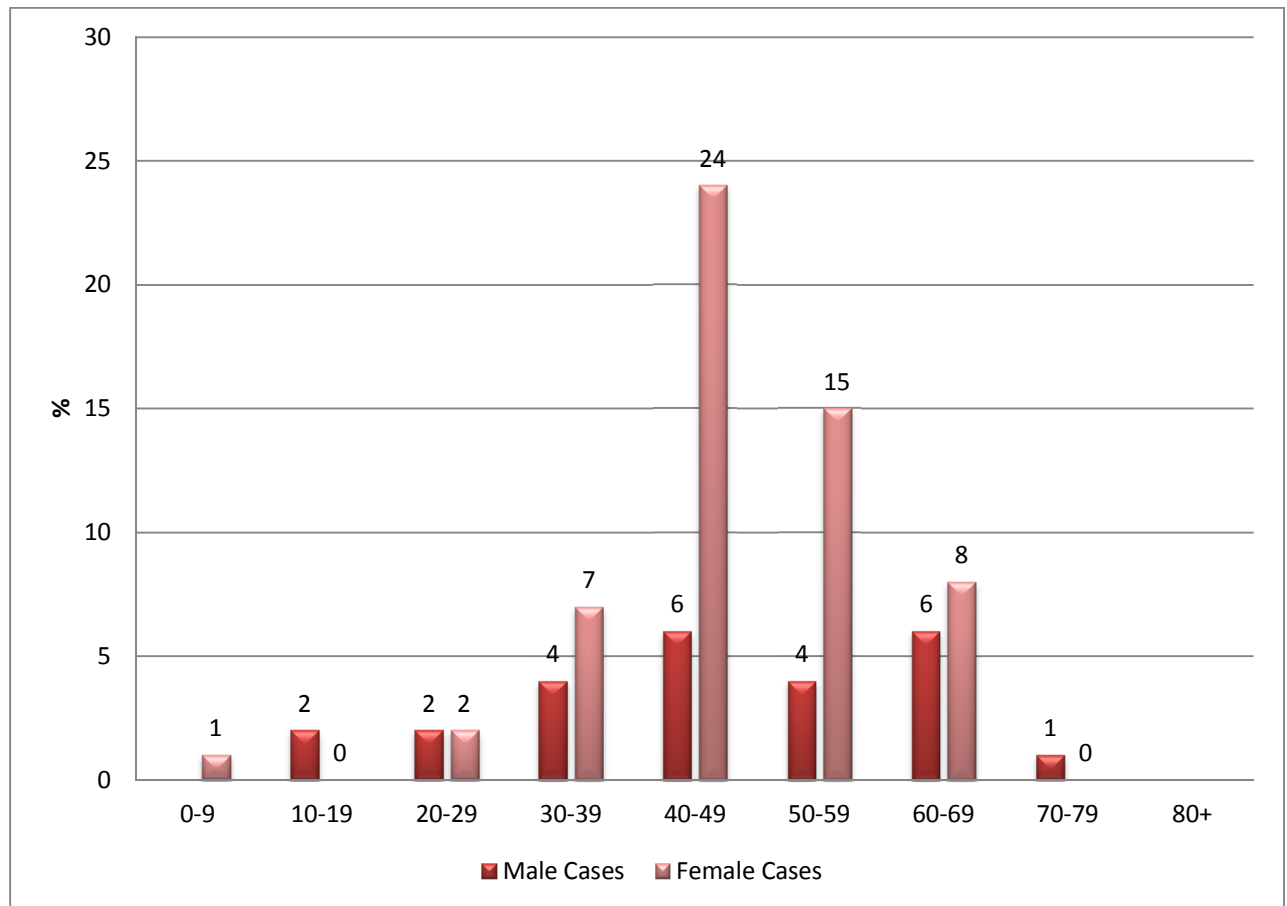


FIGURE 10 DISTRIBUTION BY AGE AND GENDER

Analysis of distribution based on age and gender shows female predominance between age 30 to 69 years while men were present at the extreme ranges of age:(10 – 19) years, and (70-79 years).

II. Clinical results:

A. Past history :

Of the 100 cases studied, 3 patients have been diagnosed with mild cranial trauma, and 9 patients have reported hyper estrogenic status: (uterine fibroid (3 CAS), breast cancer (1 case), endometrial cancer (1 case), a pregnant woman at 26 weeks of gestation, one women who has just given birth one week-earlier, history of ovarian cyst(2cases).

Past history of our patients are the following:

<u>Medical</u>	<u>surgical</u>	<u>Toxic</u>
HTA : 14%	Cholecystectomy: 5 %	Tabac: 11%
Diabetes : 8%	Appendectomy: 2%	Alcohol: 2%
Hormonal imbalance: 9%	Thyroidectomy: 3%	
lung tuberculosis:1%	hydatid cyst: 1%	
Asthma: 3 %	eye disease: 3%	
	hernia: 4%	

TABLE 3 PAST HISTORY OF OUR SERIES

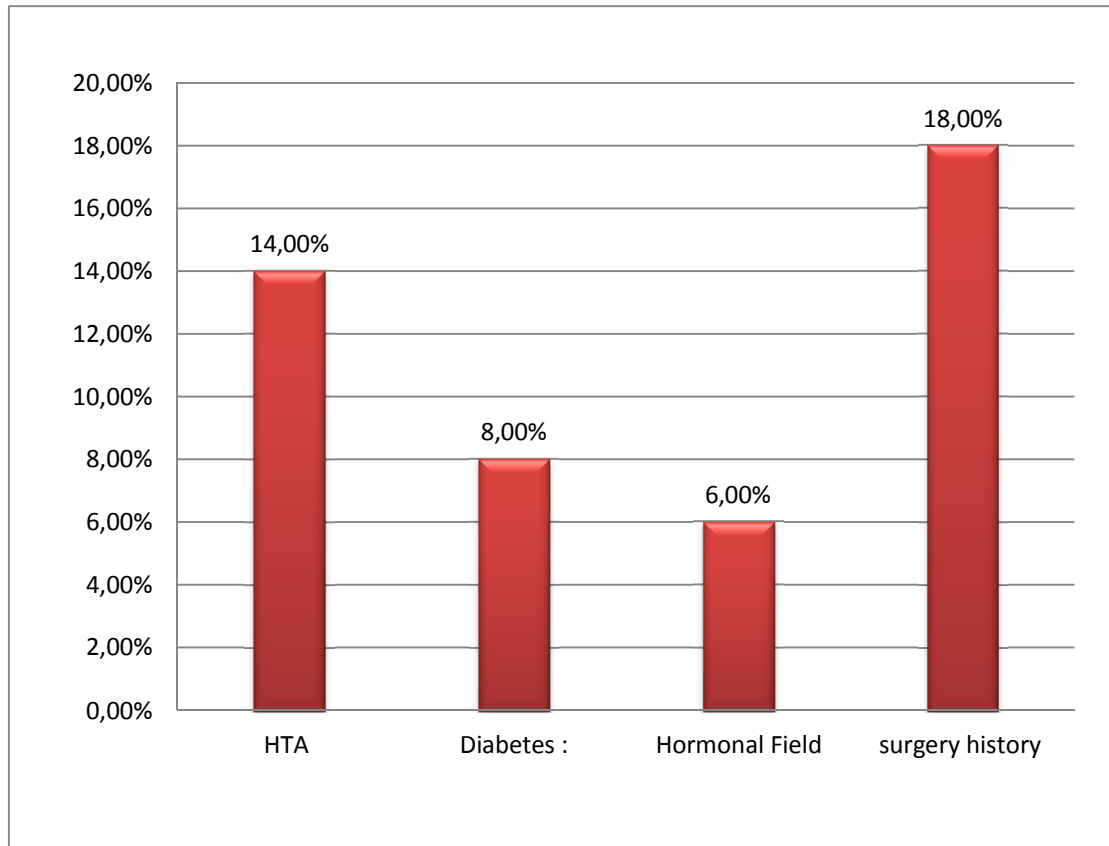


FIGURE 11 PATIENT PAST HISTORY

B. Diagnosis delay:

The diagnostic delay is the time from the onset of the first symptom to the admission of the patient at hospital; the mean diagnosis delay is 17 months with extremes ranging from 1 month to 120 months.

Preoperative delay	cases	Percentage (%)
≤ 3 months	18	18%
3 months-1 year	50	50%
> 1 year	32	32%

TABLE 4 DIAGNOSIS DELAY

C. Clinical presentation

1. Functional signs:

-Visual impairment: 83% of patients presented with visual impairment, this was the main revealing symptom, with either brutal or progressive decreasing.

-Headache: 81% (n=81).

-Vomiting: 34% (n=34).

-Behavior disorder: 15% (n=15).

-Memory impairment: 15% (n=15).

-Seizures: 12% of patients presented with seizures, whether they were partial or generalized, isolated or associated to other neurological symptoms.

-Anosmia or hyposmia: Smell disorders either anosmia or hyposmia, are most often assessed on-physical examination, this deficit is not always perceived by the patient mostly when it is unilateral. It is otherwise perceived as a loss of taste. 13 % (n=13) had smell disorders at admission.

-Exophthalmos results: 14% (n=14).

-Diplopia: 5% (n=5).

-Endocrinological signs:

Only one patient in this study was having an endocrinological manifestation: galactorrhea, this patient was presenting a suprasellar meningioma.

2. Physical examination:

2.1.GCS:

The state of consciousness of our patients is evaluated according to the GCS (The Glasgow score), and it is represented at the following table:

Glasgow score	Number of patients	%
GCS= 15	96	96%
$8 \leq \text{GCS} \leq 14$	4	4%
$\text{GCS} \leq 8$	0	0 %

TABLE 5 THE GLASCOW SCORE OF OUR SERIES

-At the admission, most of the patients in our series had a normal conscious status, except for 4 patients who had a GCS inferior to 14.

2.2.Motor deficit:

-15 patients were found with motor deficit including 13 with hemiparesis and 2 with hemiplegia (1 case with orbital roof, size=7.23cm, second case with greater sphenoidal wing size= 8cm).

2.3.Aphasia and memory disorders:

- Superior functions impairment was found in 17 cases, (17%), 3 cases with phasic disorders and 15 cases with memory deficit.

2.4.Nerve deficit:

2.4.1. Optic nerve:

Visual acuity was assessed in 95 patients, it was not possible to determine in the 4 patients having GCS inferior to 14, and it was not available in one patient data.

83 % of patients had a decreased vision.

The worst cases scenarios in our series were :

- Blindness in both eyes: 3 cases (**3.2%**).
2 cases of OGMs, and one case of ACPMs.
- Both eyes preblindness: 26 cases (**27.4%**).
6 cases of OGMs, 11 cases of planum sphenoidale, 4 cases of TSMs, one case of diaphragma sellae , 3 cases of ACPs and one case of the greater sphenoid wing.

Thus, almost the third of the patients were considered as legally blind. 29 cases (30.5%),

Other vision impairment was found as follow:

-14 patients had monocular blindness and 27 patients had monocular preblindness.

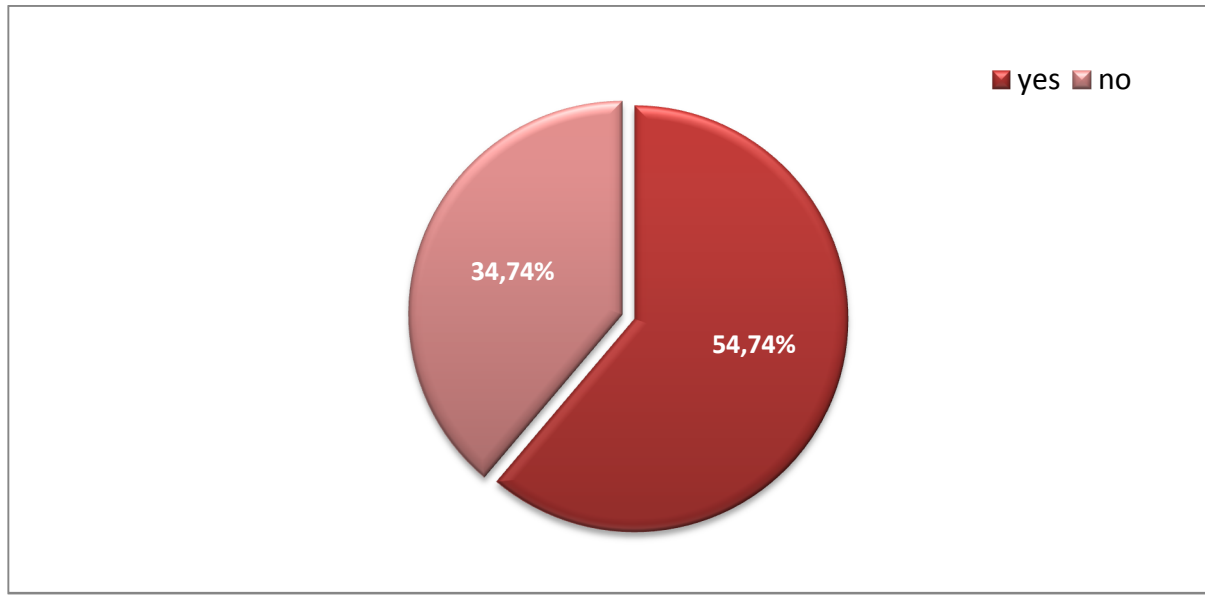


FIGURE 12 BOTH EYES IMPAIRMENT

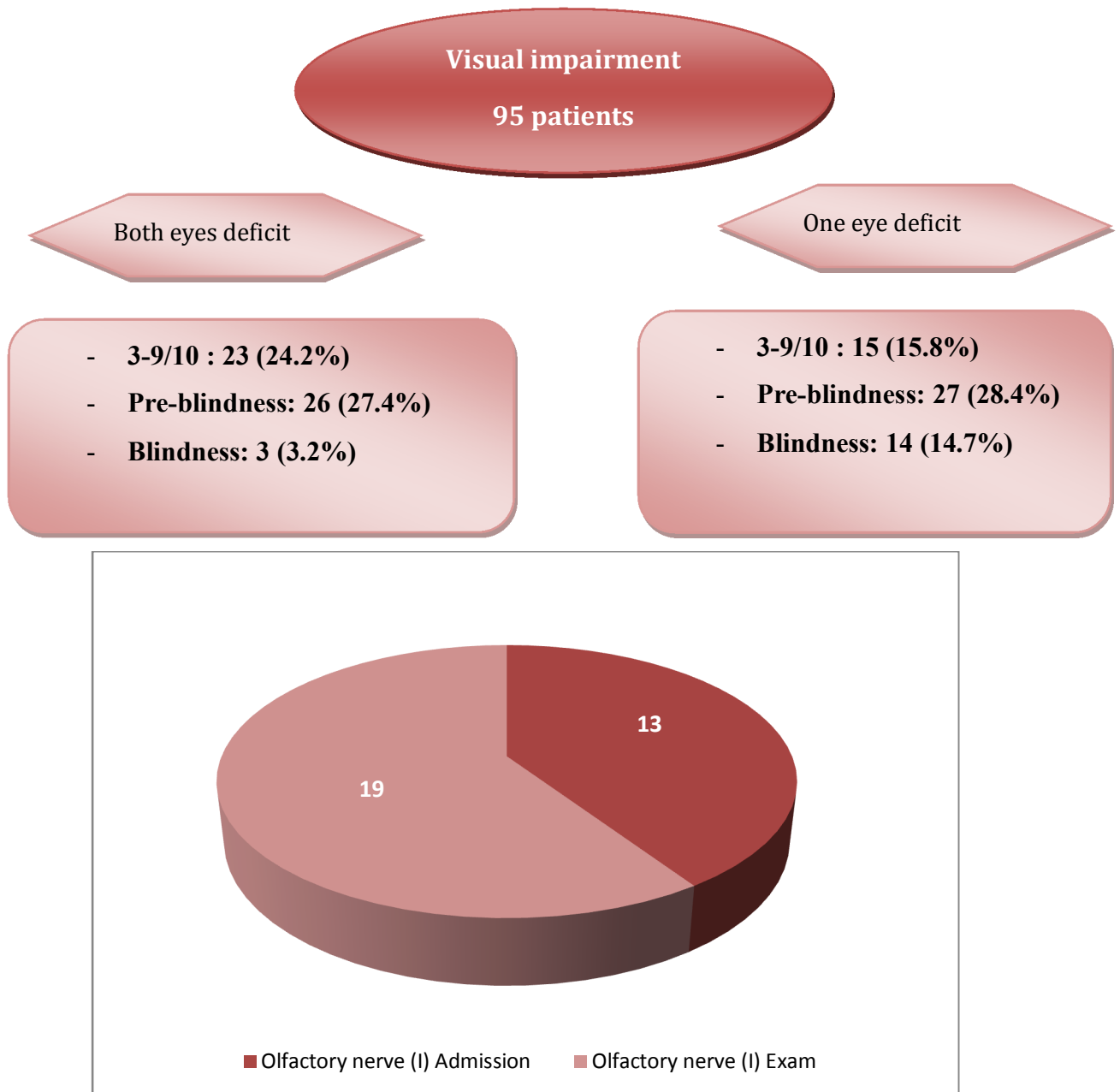


FIGURE 13 OLFACTORY NERVE

As mentioned above, only 13 patients reported anosmia or hyposmia at admission, while 19 patients were discovered to have impairment in olfactory functions at physical examination.

2.5.1. Other nerve damage:

Nerve	Oculomotor nerve (III)	Trochlear nerve (IV)	Trigeminal nerve V	Abducens nerve (VI)
Cases	11	4	3	5

TABLE 6 NERVE DAMAGE IN OUR SERIES

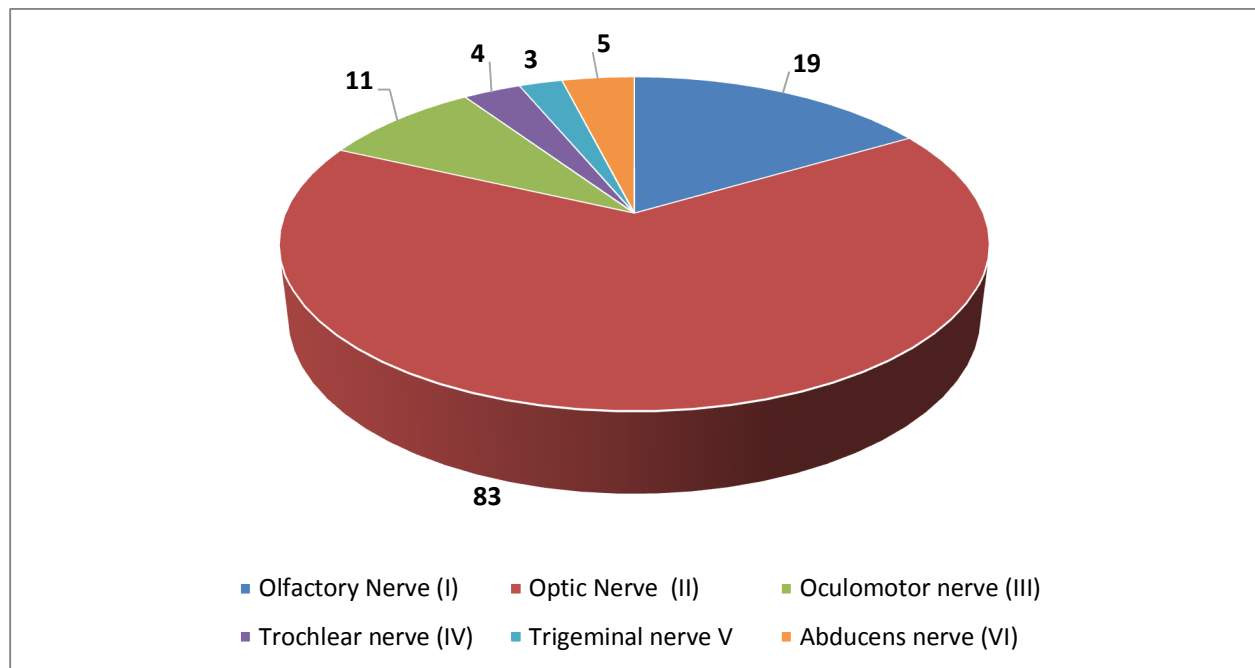


FIGURE 14 NERVE DAMAGE SUMMARY

2.6.-Visual field:

The visual field was evaluated in 36 patients, it was normal in 20 patients (55.6%).

	Bitemporal hemianopia	homonymous hemianopia	lateral temporal hemianopia	scotoma
Cases (%)	4 (11.11%)	3(8.3%)	4(11.1%)	1(2.8%)

TABLE 7 VISUAL FIELD IN OUR SERIES

2.7.Fundus results:

The fundus was evaluated in 84 patients, these are the results

	Optic Atrophy	Papillary Odema	White spots	Papillary pallor	Unilateral papillary oedema+optic atrophy	Papillary hyperaemia
%	10	31	1	22	2	4

TABLE 8 FUNDUS RESULTS

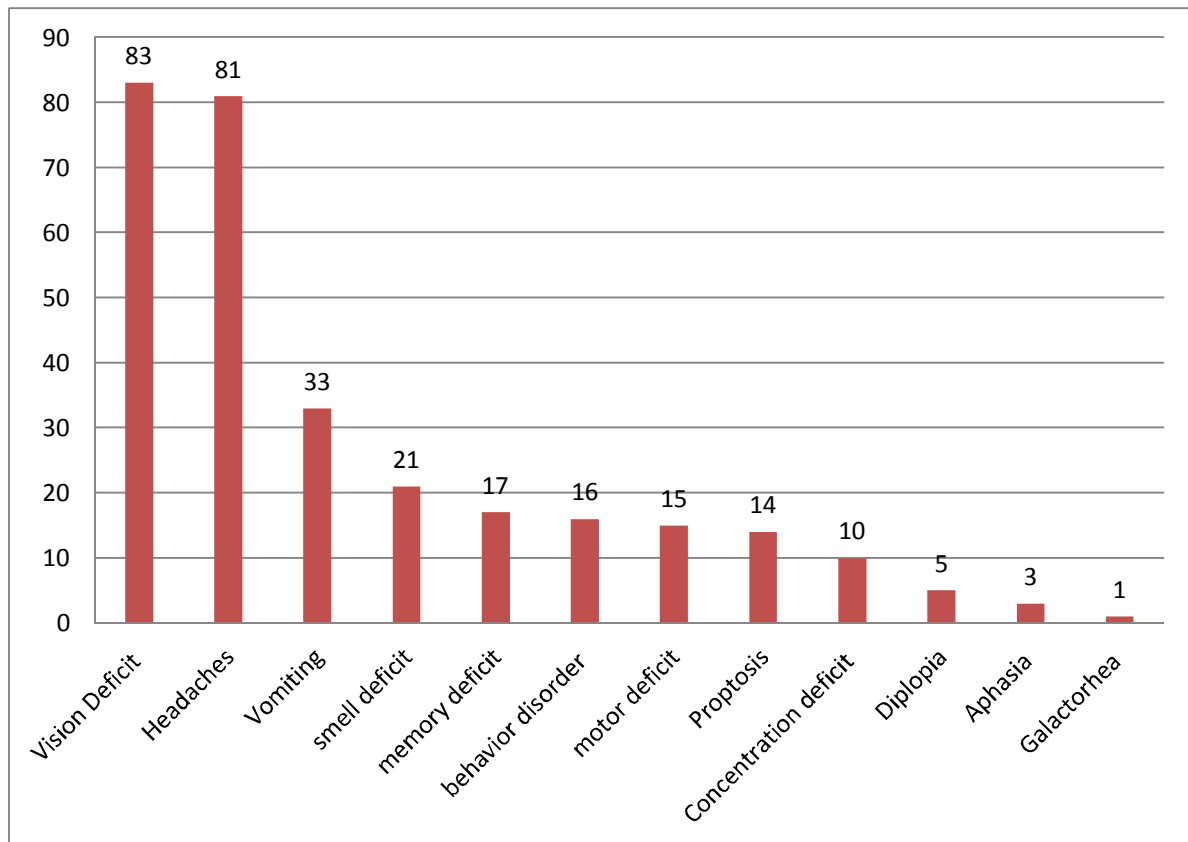


FIGURE 15 SUMMARY OF CLINICAL PRESENTATION IN OUR SERIES

3. Clinical presentation based on meningiomas location :

The results were classified by the meningioma's topography, and they are the following:

	Anterior Fossa		Middle Fossa										Total
	Olfactory Groove	Orbital roof	Suprasellar			Lateral sellar		Sphenoid Wings				En Plaque	
								Lesser sphenoid wing			Greater sphenoid wing		
			Planum Sphenoidal	Diaphragma sellae	Tuberulum sellae	cavernous sinus	Posterior clinoid process	Anterior clinoid process	middle sphenoidal wing	External sphenoid wing			
Number of patient	14	2	34	3	5	4	1	15	2	2	10	8	100
RICP	12	2	25	1	5	3	1	12	2	2	6	1	72
Headaches	13	2	27	2	5	4	1	14	2	2	7	2	81
Vomiting	6	2	9	1	4		1	3	1		4	2	33
Vision impairment	11	1	28	3	5	3	1	11	2	2	8	8	83
Behavior Disorder	5	1	5					4		1			16
Concentration disorder	2	1	4					3					10
memory disorder	3	1	7		1			4			1		17
Deficit	1	1	4					5			4		15
seizure	3	2	4					1			2		12
Endocrinological signs				1									1
proptosis			1		1	2		1			2	7	14
`diplopia	1					2					1	1	5
Aphasia or disarthia			1								2		3
GCS<15			2								1	1	4
I	8	2	9		1			1			1		21
III	2		2		1	3					2	1	11
IV			1			2					1		4
V						2		1					3
VI			1			1		2			1		5

TABLE 9 CLINICAL PRESENTATION BY LOCATION

Anterior and middle skull base meningiomas

	Anterior Fossa		Middle Fossa										Total
	Olfactory Groove	Orbital roof	Suprasellar			Laterosellar		Sphenoid Wing				En Plaque	
								Lesser sphenoid wing			Greater sphenoid wing		
			Planum Sphenoidale	Diaphragma sellae	Tuberulum sellae	cavernous sinus	Posterior clinoid process	Anterior clinoid process	middle sphenoidal wing	External sphenoid wing			
<u>Visual deficit</u>													
<u>Both eyes</u>	12	2	15	1	4	2	1	6	1	2	5	1	52
03-09	4	2	4	1		2	1	2	1	2	4	1	24
preblindness	6		11	1	4			3			1		26
Blindness	2							1					3
<u>One eye</u>	1		12	1	1	1		5	1		3	7	32
03-09	1		5	1	1	1		1	1		3	1	15
Preblindness			10	1	1	1		5			2	7	27
Blindness	1		6					3				4	14
<u>Fundus Exam</u>													
normal	3	1	7		1	2		4			2	1	21
Papillary edema		1	11		8	1		4		1	3	2	31
Optic atrophy			6	2	3							1	12
Papillary palor	3		7	1	3		1	4	1		1	1	22
Papillary hyperemia									1	1	2		4
white spot						1							1
<u>Visual Field</u>													
Unilateral hemianopiatemporal			3						1				4
Bilateral hemianopiatemporal			3	1									4
Homonymous hemianopia					1		1				1		3
Scotoma			1										1

TABLE 10 PHYSICAL EXAMINATION BY LOCATION

III. Imaging results:

The neuroradiological assessment includes:

- Plain X ray;
- CT head scan;
- MRI;
- MR spectroscopy.
- Cerebral angiography.

A. Neuroradiologic features of meningiomas in our series :

1. Plain X rays:

Plain x-ray was performed in 3 patients. intra-tumor calcifications were found in one case.

2. CT head scan:

Ct scan was performed in all patients. It revealed the diagnosis of meningioma in 91 cases, (in 9 cases Ct scan described a glioma , pituitary adenoma, Macroadenoma , carotid aneurysm, astrocytoma, craniopharyngioma as a differential diagnosis).

- The lesion was spontaneously hyperdense in **74%** (n=74), isodense in **22%** (n=22), and hypodense in **4%** (n= 4).
- After injection of contrast, most of these tumors had homogeneous contrast enhancement (65%) and **15%** of tumors were heterogeneously enhanced.
- The mean size is 3,62cm, ranging from 2,05 cm to 11 cm.
- Intralesional calcifications were found in **32%** (n=32).
- Cystic component was found in **4%** (n=4).
- Perilesional edema was detected in **59%**. (n=59).
- Bone reaction was observed in **29%** (n=29).

Features		Percentage
Contrast	Homogenous	65
	Heterogenous	15
Density	hyperdense	74
	isodense	22
	hypodense	4
calcifications		32

Perilesional edema	59
Mass effect	73
Bone reaction	29
cyst	4

TABLE 11 SUMMARY OF CT SCAN FEATURES**3. MRI:**

The MRI was performed in all our patients.

- T1: hypointense in 35 %, isointense in 59% , hyperintense in 5%.
- T2: hypointense in 9%, isointense in 17% , hyperintense in 74% .

Gadolinium injection was performed in all the patients, and as a result intense enhancement was seen in all cases.

	MRI features	Percentage (%)
T1	Isointense	59.74
	Hypointense	35
	Hyperintense	5.19
T2	Isointense	16.88
	Hypointense	9
	Hyperintense	74.02
perilesional edema		78%
Calcification		23%
mass effect		86%

TABLE 12 MRI FEATURES IN OUR SERIES

Fossa	Location		Mean size cm
Anterior fossa	Olfactory groove		5.11
	Roof of orbit		2.95
Middle fossa	suprasellar	Tuberculum sellae	3.49
		Planum sphenoidale	3.67
		Diaphragma sellae	3.15
	laterosellar	cavernous sinus	2.05
		posterior clinoid process	6
	Sphenoid wings	Lesser sphenoid wing	Inner third sphenoid wing / anterior clinoid
			Middle third or alar meningiomas
			External third or pterional meningiomas
		Greater sphenoid wing	
En plaque			2.61

TABLE 13 DISTRUBUTION OF THE MEAN SIZE BY LOCATION

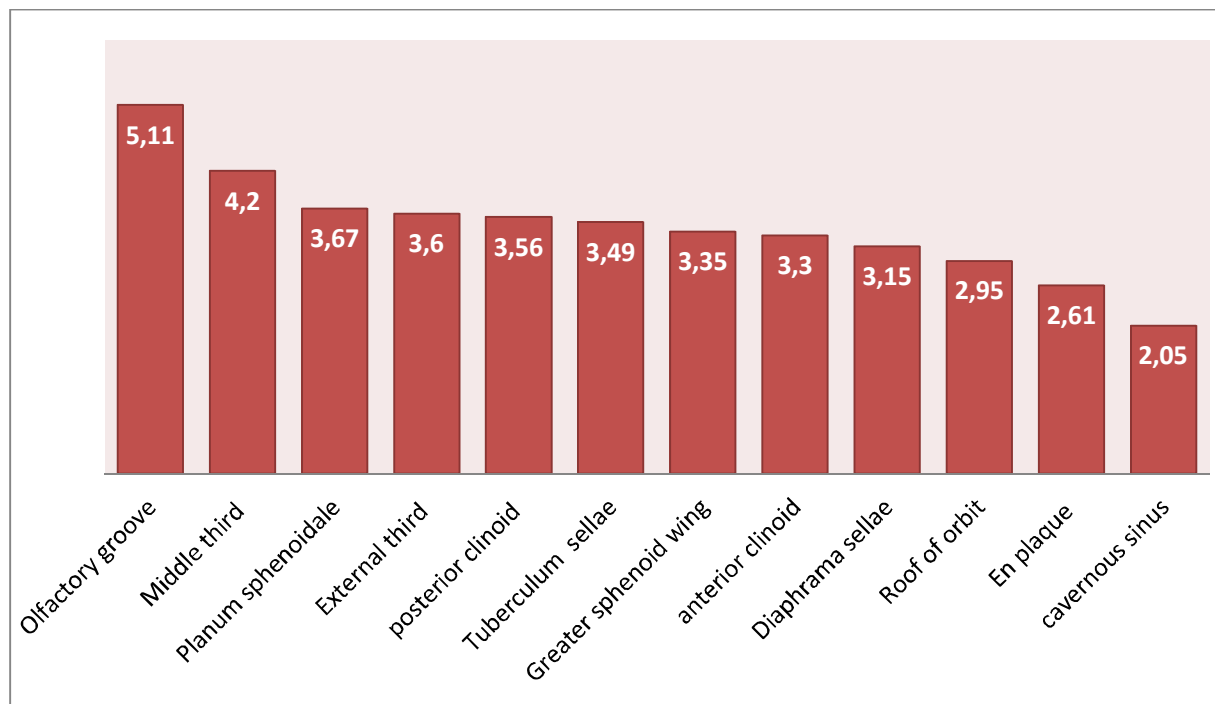


FIGURE 16 MEAN SIZE BY LOCATION

Examples of MRI meningiomas:



FIGURE 17 MRI PLANUM SPHENOIDALE MENINGIOMA



FIGURE 18 MRI T1 EXTERNAL SPHENOIDAL WING MENINGIOMA

4. MR spectroscopy :

It was performed in 6 patients as a result an increased alanine , increased glutamine-glutamate and increased choline (Cho) were found.

5. Cerebral angiography:

It was performed in 48 patients:

Angiographic signs	Cases	Percentage (%)
tumor injection	48	100
Vascular displacement	48	100
Blush tumor	27	56.25

TABLE 14 ANGIOGRAPHIC SIGNS IN OUR SERIES

B. NeuroRadiologic results by location:

Anterior fossa	Olfactory groove		14
	Orbital roof		2
Middle fossa	Suprasellar	Tuberculum sellae	5
		Planum sphenoidal	34
		Diaphragma sellae	3
	Laterosellar	Cavernous sinus	4
		posterior clinoid process	1
	Sphenoid wings	Lesser sphenoid wing	15
		Middle third or alar meningiomas	2
		External third or pterional meningiomas	2
		Greater sphenoid wing	10
En plaque	Sphenoorbital		8

TABLE 15 DISTRIBUTION OF PATIENTS BY LOCATION

We classified the size as follow:

	Location		[0-3]	[3-6]	> 6	
Anterior fossa	Olfactory groove		2	5	7	
	Orbital roof		1		1	
Middle fossa	Suprasellar		Tuberculum sellae	2	3	
			Planum sphenoidale	14	15	5
			Diaphragma sellae	1	2	
	laterosellar		Cavernous sinus	3	1	
			Posterior clinoid process		1	
	Sphenoid wings		Inner third sphenoid wing	5	8	2
			Middle third or alar meningioma		2	
			External meningiomas		1	1
			Greater sphenoid wing	2	4	4
	En plaque		4	4		
	Total			34	46	20

TABLE 16 SIZE OF MENINGIOMA BY LOCATION

	Anterior fossa		Middle fossa										
	Olfactory Groove	Orbital roof	Suprasellar			Laterosellar		Sphenoid Wing				En plaque	Total
								Lesser sphenoid wing			Greater sphenoid wing		
			Planum Sphenoidale	Diaphragma sellae	Tuberulum sellae	cavernous sinus	Posterior clinoid process	Anterior clinoid process	middle sphenoidal wing	External sphenoid wing			
<u>CT scan</u>													
hyperdense	10	2	25	3	2	2	1	12	1	2	7	7	74
hypodense					1	1		1				1	4
isodense	4		9	0	2	1		2	1		3		22
Contrast	14	2	33	3	5	4	1	14	2	2	10	8	98
Calcification	5	1	13		1			5		1	3	3	32
Perilesional edema	10	1	18	1	3	2	1	7		2	7	7	59
Bone reaction	6	1	6	1				4		1	5	5	29
<u>MRI</u>													
Mean Size in cm	5,23	5.09	4.06	3.23	3.46	2.8	3.56	4.48	4.21	4.86	5.16	3,66	
T1													
Hyperintense	2				1	1							4
isointense	3	1	19	3	2	3		5	1	2	4	3	46
Hypointense	4		9		1		1	6	1		1	4	27
T2													
Hyperintense	7	1	18	2	4	2	1	9	2	1	5	5	57
hypointense	1		4					1		1			7
isointense	1		6	1	0	2		1				2	13

TABLE 17 NEURODARIOLOGIC FEATURES BY LOCATION

IV. Laboratory investigation:

The use of routine laboratory studies, including complete blood count, coagulation studies, and electrolytes, as a preoperative evaluation tool remains systematic. That was performed in all the patients.

Meningiomas of the suprasellar or hypothalamic region also warrant an endocrinology evaluation to assess for hormone abnormalities related to pituitary stalk effect or hypothalamic compression. Workup should include evaluation of thyroid function (thyroid-stimulating hormone [TSH] and free T4), growth hormone function (somatomedin-c), serum prolactin, random or morning cortisol level, and possibly testosterone function if clinically indicated.

V. Treatment:

A. Surgical management :

The several parameters of surgical treatment were deducted from the patients operative reports.

1. Preoperative management

Corticotherapy (methylprednisolone) is commonly used to manage perilesional edema; in fact, it was prescribed 3 or 4 times per day, 3 days before surgery.

The ultimate goal of preoperative medical assessment is to reduce the patient's surgical and anesthetic perioperative morbidity or mortality. It involves the assessment of information from multiple sources, including medical records, patient interviews, physical examinations, and findings from preoperative tests. The patients are classified into 6 classes by the American society of anesthesiologists (ASA).

ASA I	A normal healthy patient
ASA II	A patient with mild systemic disease
ASA III	A patient with severe systemic disease
ASA IV	A patient with severe systemic disease that is a constant threat to life
ASA V	A moribund patient who is not expected to survive without the operation
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes
E	Emergency surgery

TABLE 18 ASA CLASSIFICATION

This classification was obtained in 64 patient's data, 56 of these patients were class I (87.50%) and 8 were class II(12,50%).

before surgery preoperative labs is required; all the patients in this study completed these tests:

- Blood tests such as a complete blood count (CBC);
- Glycemia and blood type test;
- Electrolytes test blood;
- Coagulation test;
- Chest X-Ray;
- Electrocardiogram (EKG);

The day before surgery, premedication based on hydroxyzine, 1mg/kg or Benzodiazepines, is not systematically given to the patient.

Preparatory embolization, a technic used for tumors that have an extensive blood supply, may help reduce bleeding during surgery. It was performed in 2 patients with:

- Lesser sphenoid wing: middle variety meningioma.
- Greater sphenoid wing meningioma (GSW).

2. Surgical technique

2.1. Position:

The Supine position: The dorsal decubitus with slight rotation and light extension of the head was the usual position. The head placed on the Mayfield head holder.

2.2 Surgical approaches:

Surgical management and approach depends on location and extension of the meningioma.

2.2.1. Anterior fossa: (n=16).

Subfrontal approach

Indications:

Unilateral subfrontal approach was used in 10 patients having an anterior fossa meningioma. Bifrontal approach was used only in one patient. Through the years, we favored the use of unilateral approach instead of bilateral approaches.

3 cases had an extended fronto-orbito-zygomatic approach.

Technique:

Patient is carefully placed in the supine position with the knees slightly flexed and the head elevated, held with the Mayfield-kees three point skeletal fixation headrest. A coronal incision is made through the galea. The dural incision is made over each medial inferior frontal lobe just above the anterior edge of the craniotomy opening, allowing good exposure. Then the frontal lobes are carefully protected and retracted, the sagittal sinus is ligated between two silk sutures and the falx is cut and the bridging veins from the anterior frontal lobe to the midline area are coagulated and cut. The tumor will come into view in the midline. The attachments of the tumor along the base of the frontal fossa are gradually dissected, interrupting blood supply that enters the tumor through numerous openings in the bone in this region. The main problem in this area is the dissection of the posterior portion of the capsule which is reflected anteriorly while looking for the pericallosal branch of the anterior cerebral artery complex. The frontopolar branch and other small branches are often adherent to the tumor or enter capsule and may need to be divided.

Pterional approach:

It was performed in one patient, this approach will be described below.

2.2.2. Middle fossa: (n=84).**SubFrontalapproach :**

As described above, it was used in 20 patients.

Pterional approach:

It was performed in 60 cases, the patient is placed supine, and the operating table is flexed to place the head above the level of the heart to facilitate venous drainage. The head is slightly rotated toward the contralateral shoulder; there are 3 types of incisions used in this series.

Skin incision is started from the zygomatic arch, less than 5 mm anterior to the tragus to avoid injury of the frontal branch of facial nerve, which courses over the zygomatic arch more anteriorly. Goes upward and forward back to the hairline and loops backward for 1 or 2 cm on the opposite side of the midline. This approach provides adequate cranial exposure and keeps the incision off the forehead.

	SubFrontal		Pterional	OZA	subtemporal	interhemispheric
	Unilateral	Bilateral				
Anterior fossa	11	1	1	3	0	0
Middle fossa	19	2	60	1	1	1

TABLE 19 SURGICAL APPROCHES IN OUR SERIES

Our intraoperative photographs demonstrating a frontotemporal approach and steps followed in an external sphenoid wing meningioma. A 50 years old female patient, , presenting with apathia, raised intracranial pressure and hemiparesis at the left side.

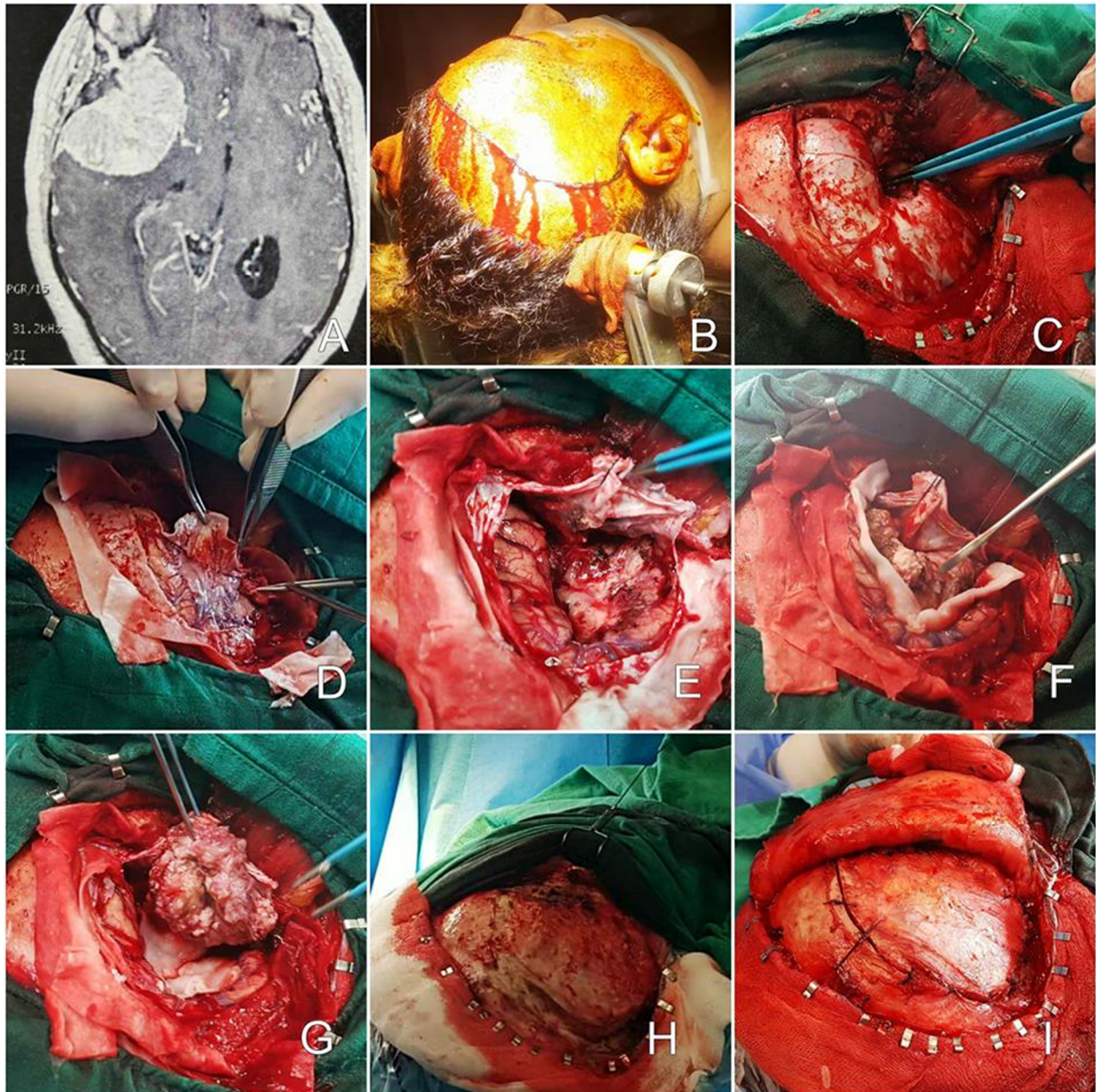


FIGURE 19 OUR INTRAOPERATIVE PHOTOGRAPHS OF AN EXTERNAL SPHENOID WING MENINGIOMA SURGERY

(A) Magnetic resonance imaging of the patient with an external sphenoid wing meningioma. (B) The patient is positioned with slight rotation of the head 15°, skin incision of a frontotemporal approach (C) resection and drilling of hyperostotic sphenoid wing (D) Dural opening (E) Dural suspension (F) Cortex and tumor separation (G) Careful dissection of the tumor (using coagulation, suction and defragmentation) (H) Bone flap fixation (I) Bone closure of temporal muscle and aponeurosis.

2.3. Macroscopic aspect:

The color of tumor was described in 38 patients data's, the results were:

Macroscopic color	Cases
White	10
Yellow	11
Grey	9
Pink and red	13

TABLE 20 MASROSCOPIC COLOR DESCRIBED IN THE OPERATIVE REPORT

We think these results don't reflect the true color of the tumor rather than how every neurosurgeon sees the color.

The following figure shows a macroscopic aspect of the patient who underwent surgery for the ESWMS



Our intraoperative photographs, showing a microscopic aspect of ESWMs

2.4. Resection:

The main surgical challenge in treating meningioma of skull base is to excise the tumor totally without causing mortality or morbidity, and this is due to the proximity of neurological structures (cranial nerves) as well as the vascular structures (arteries and veins) . The extent of resection is classified according to Simpson score:

Grade	Extent of Resection
I	Gross total resection of tumor, dural attachments, and abnormal bone
II	Gross total resection of tumor, coagulation of dural attachments
III	Gross total resection of tumor, without resection or coagulation of dural attachments, or of its extradural extensions
IV	Partial resection of tumor
V	Simple decompression (biopsy)

TABLE 21 SIMPSON SCORE

The results of our series are as follow:

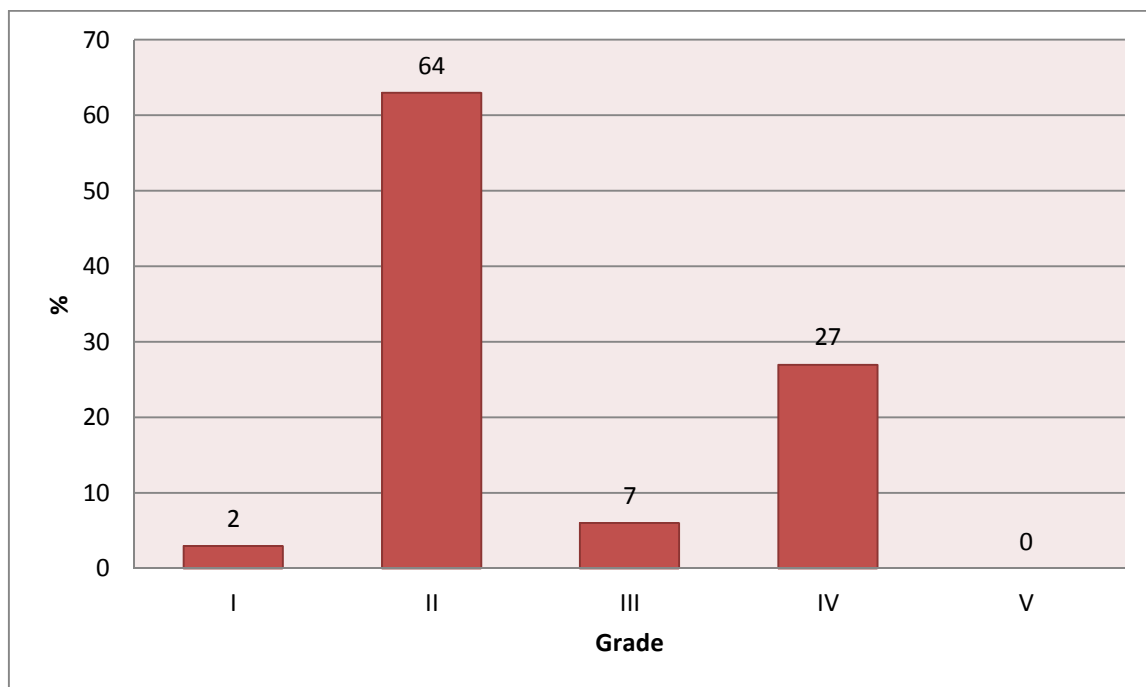


FIGURE 20 SIMPSON GRADE

Fossa	Localization		I	II	III	IV
Anterior fossa	Olfactory groove		1	10	1	2
	Orbital roof			2		
Middle fossa	Suprasellar	Tuberculum sellae		4		1
		Planum sphenoidale		28	1	5
		Diaphragma sellae		3		
	Laterosellar	Cavernous sinus				4
		Posterior clinoid process		1		
	Sphenoid wings	Lesser sphenoid wing	1	6	2	6
				2		
				1		1
		Greater sphenoid wing		5	1	4
En plaque				2	2	4

TABLE 22 RESECTION BY LOCATION

Grade I Simpson is not usually performed in skull base meningiomas given the uneasiness of its repair.

2.5. Surgery duration :

The mean duration of surgery was 5h40min with extreme ranging from 2 hours to 08h 30min.

2.6. Intraoperative incidents:

74% of patients, the procedure was carried out without incidents, while 25% encountered perioperative complications represented mainly by excessive bleeding and one patient had disseminated intravascular coagulation (DIC).

Intraoperative incidents	Percentage
No incidents	74%
Bleeding	25%
DICV	1%

TABLE 23 INTRAOPERATIVE INCIDENTS

The perioperative transfusion was administrated in 75 patients, with a mean dose of 2.76 RBC, the extreme ranging of (1RBC, 6RBC).

3. Postoperative care:

3.1.Corticotherapy:

It was systematically given to all our patients in order to reduce and prevent cerebral swelling, methylprednisolone was used at a loading dose of 2 mg/kg per day divided into 3 doses, it was maintained for at least 5 days with gradual regression and stopped on the 7th day.

3.2.Antibiotherapy:

Antibiotic prophylaxis was administered systematically before incision.

3.3. Anticonvulsants:

Antiepileptic medication was continued during the perioperative period in patients with a known history of seizures.

3.4.Anticoagulant treatment:

3.4.1. Preventive anticoagulant therapy:

It was postoperatively given in patients with or without a risk of developing thromboembolic disease, including bedridden patients, those with neurological deficit or those with risk factors, using calcium heparin or low molecular weight heparin.

3.4.2. Curative anticoagulant therapy:

Heparin (heparin sodium) was prescribed in patients with phlebitis of the lower members for 5 to 10 days relayed by vitamin K antagonists during a period of 6 months.

3.5.Insulin therapy:

It has been adapted in pre and postoperative in all our diabetic patients.

3.6.Analgesic drugs :

They are administered to relieve pain for the patients. They were used in all the patients of our series.

B. Radiosurgery:

1. Indications in our series:

Radiosurgery was indicated in 26 patients.

The indication were:

- 7 patients Simpson grade II;
- 19 patients with partial resection including: 17 Simpson VI, and 2 Simpson III.

2. Surgical technique:

2.1. Volume:

Mean volume is 12.36cc; ranges are (19cc-2,5cc).

2.2. Dose:

Mean dose was 10.625Gy (ranges 11-14Gy), the patients were followed by clinical examination as well as a magnetic resonance imaging (MRI) at the 6th months after the radiosurgery.

3. Intraoperative incidents:

Post radiosurgery nausea or other immediate symptoms were rare.

4. Postoperative care:

Corticotherapy is systematically given in all patients in order to reduce and prevent cerebral swelling; methylprednisolone was used and administered initially at a loading dose of 2 mg/kg per day.

5. Results of treatment

We classified the Tumor Response to Radiosurgery as the following:

- Very good results with decreased volume: 3 patients.
- Good results with stabilization of growth: 18 patients.
- Poor results with progressive growth: 4 patients.

C. Radiotherapy and chemotherapy

No patients in our series underwent radiotherapy even though it was indicated in one patient with en plaque meningiomas , anaplastic grade III who died within one month.

Neither hormone therapy nor chemotherapy were prescribed in our patients.

VI. Pathology:

The final histopathological results were obtained in 96 patients.

Transitionnel meningioma	48
Meningothelial meningioma	22
Invasive Meningothelial meningioma	5
Meningothelial and transitional meningioma+atypical meningioma	3
Meningothelial and fibrous meningioma	2
Transitionnel and fibrous meningioma	3
Transitionnel and psammomatous	4
Angiomatous and fibrous meningioma	1
Angiomatous meningioma	2
Psammomatous meningioma	1
Clear cell meningioma	1
Atypical meningioma	2

TABLE 24 HISTOPATHOLOGY RESULTS IN OUR SERIES

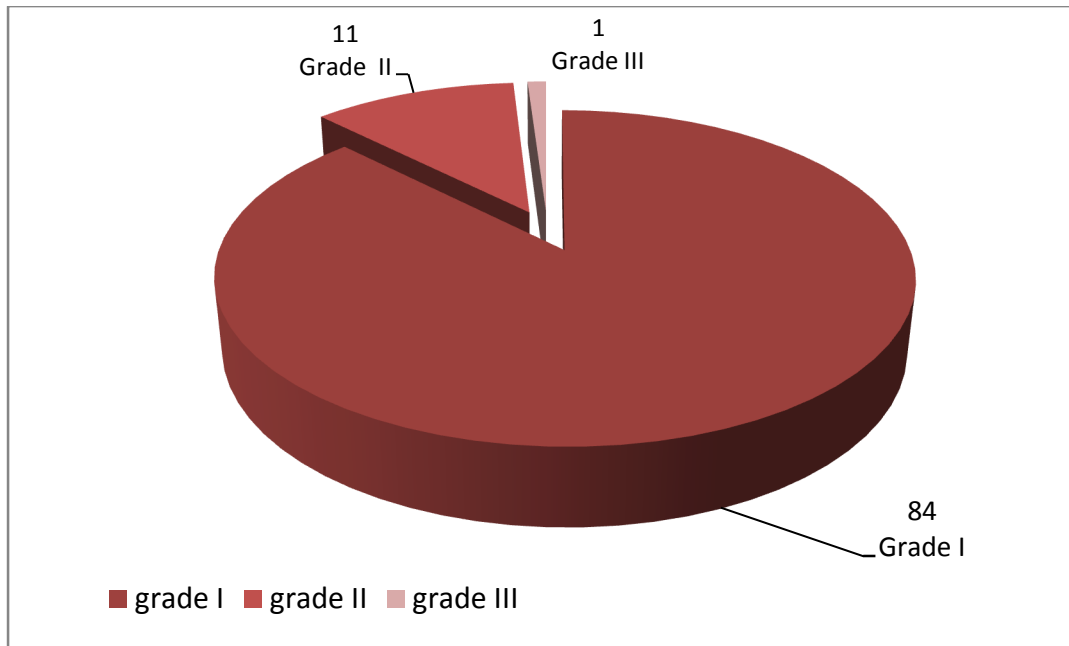


FIGURE 21 HISTOPATHOLOGY

VII. Outcome and prognosis:

A. Short term results:

1. Duration of ICU stay:

Days	Cases
0-4	57
5-15	29
>15	14

TABLE 25 DURATION STAY OF PATIENTS IN ICU

12 patients with duration of ICU stay > 15 days died.

2. Neurological outcome:

70% of patients (n=62/88) in this series were well and free of postoperative morbidity; 4.5% of patients (n=4/88) encountered multiple neurological disorders as shown in (table 26). Dead patients are excluded.

New or worsened postoperative neurological deficits and complications are summarized as follow:

		Preoperative	Postoperative		
			New	Stationary	Improve
Deficit		12	1	3	9
Proptosis		13		1	12
Behavior disorders		15		1	14
Seizure		12		1	11
Language impairment		2	2		2
Nerves	I	19	3	2	17
	III	11	1	4	7
	IV	3		1	2
	V	3		2	1
	VI	4		1	3

TABLE 26 SUMMARY OF MORBIDITY AND POSTOPERATIVE CRANIAL NERVE DEFICIT

3. Vision outcome

Vision impairment was assessed in 77 patients data (11 patients without postoperative vision control and 12 patients died are excluded).

Initial status	Outcome			
	Before surgery	Stationary	Improved	Worsened
Pre blindness both eyes	23	12	9	2
Monocular preblindness	23	6	8	8
Visual acuity>3 at both eyes	34	4	19	1
Blindness at one or both eyes	14	14	0	0

TABLE 27 VISION OUTCOME

Preblindness both eyes:

- 52% of our preblindness both eyes patients remained in the same status.
- 39% improved.
- 9% worsened.

Monocular preblindness:

- 35% of our monocular preblindness patients worsened their vision to monocular preblindness.
- 35% improved their visual status.
- 30% remained in the same status.

- Blindness at one or both eyes:

None of our patients improved their blindness.

4. Postoperative mortality:

Mortality during surgical procedure was none, and 12 patients died within one month postoperatively, we analyzed the following parameters : age , gender , past history, karnofsky scale, , location , size of tumor, edema , resection quality, surgical approach , pathology, and duration of surgery.

we calculated the p value based on the Khi 2 to define whether the factors mentioned above are significant or not.

4.1. Age, gender, past history:**➤ Age: P=0.26 , not significant;**

The mean age is 46 years with average of (6, 71).

Age	Death	Operated patients	Percentage
<10	1	1	100
10-29	1	7	14.29
30-39	2	13	15.38
40-49	1	34	2.94
50-59	4	27	14.81
60-69	2	17	11.76
>70	1	1	100

TABLE 28 AGE AND MORTALITY

➤ **Gender: P=0.68 , not significant.**

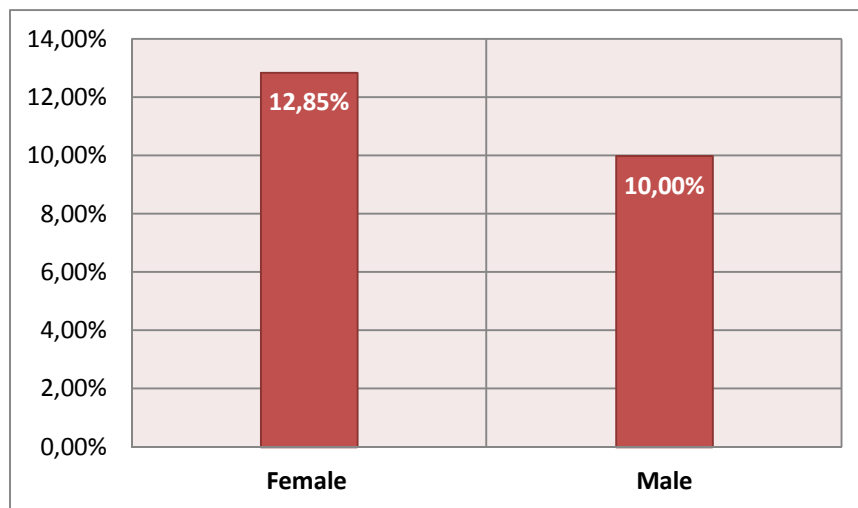


FIGURE 22 GENDER AND MORTALITY

➤ **Past history: P=0.22, not significant.**

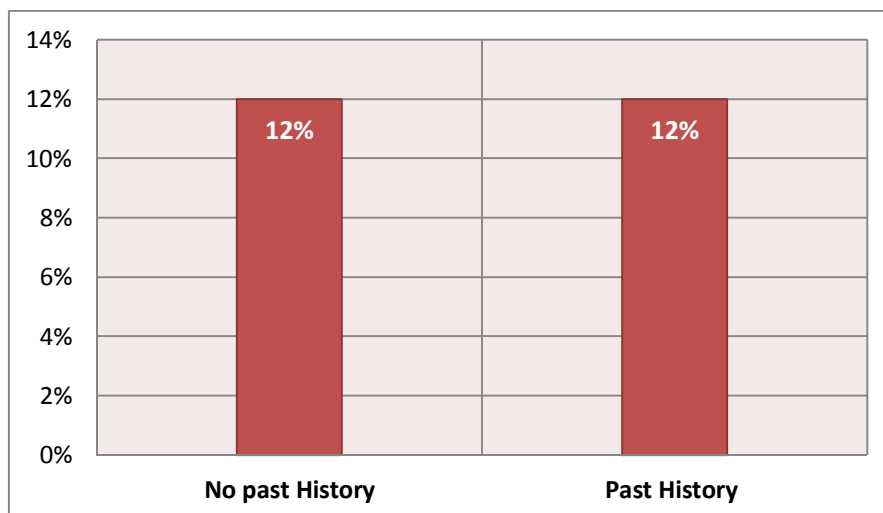


FIGURE 23 PAST MEDICAL HISTORY: DIABETES, DYSLIPIDIMIA, HBP AND MORALITY

4.2. Preoperative neurological status:

- **Karnofsky scale: P=0.005 very significant.**

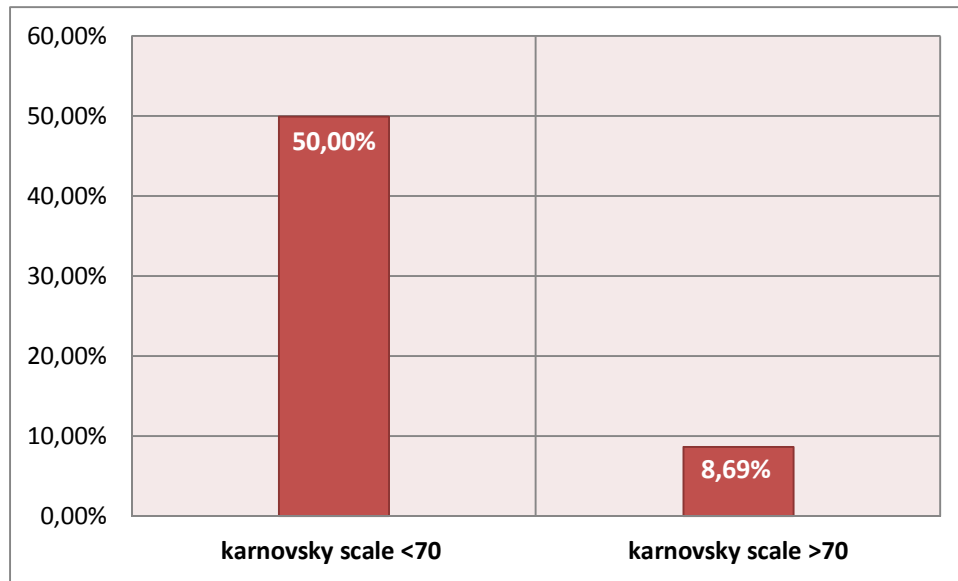


FIGURE 24 KARNOFSKY SCALE AND MORTALITY

4.3. Location, size of tumor, and perilesional edema:

- **Location: P=0.07 , borderline significance**

Olfactory groove	2 (14.28%)
Planum sphenoidale	4 (11.76%)
Greater sphenoid wing	2 (20%)
External sphenoid wing	1 (50%)
Anterior clinoid process	1 (6.66%)

TABLE 29 LOCATION AND MORTALITY

- **perilesional edema: P=0.01 very significant**

All the patients had an important perilesional edema.

- **Size>4.5cm: p=0.00000048 very significant** compared to the size of tumor >6cm.
p=0.007

All the patient who died had a tumor size>4.5cm.

4.4. Surgical approach, resection, pathology:

➤ surgical approach

	Cases (%)
Frontotemporal	9 (14.74%)
Interhemispheric	1 (100%)
Subfrontal	2 (6.06%)

TABLE 30 SURGICAL APPROACH AND MORTALITY

The number of patient having OZA, subfrontal and interhemispheric is not sufficient to conclude if any of these surgical approach is having more chance to be significant or not.

➤ Resection: P=0.68. not significant.

Simpson grade	Cases (%)
I	1 (33.33%)
II	7 (10.93%)
III	1 (16.66%)
IV	3 (11.11%)

TABLE 31 SIMPSON GRADE AND MORTALITY

➤ pathology : P=0.02 . the grade is significant.

Simpson grade	Cases (%)
I	9 (10.71%),
II	2 (22.22%)
III	1 (100%)

TABLE 32 PATHOLOGY AND MORTALITY

4.5. Duration surgery:

Duration of surgery in patients with available data was over 6hours .

Conclusion:

Clinical and surgical factors univariately associated with a decreased progression-free survival are : karnofsky scale<70, important perilesional edema, size of tumor>4.5cm, pathology, location was of borderline significance (P =0.07).

	Age	Gender	Karnofsky at admission	Diagnosis Delay (months)	Size Cm	Edema	surgical approach	Simpson	Duration of surgery	Who grade	Perioperative incidents	Immediate Postoperative complication
1	60	F	<70	12	8	yes	FT	IV	NA	II	DICV	Epistaxis , shock , DIC , hemoptysis
2	64	M	>70	8	4,7	yes	FT	II	6h	I	No	Pneumopathy+ bilateral frontal ischemia
3	39	F	>70	6	>6	yes	FT	IV	6h	I	Bradycardia and massive bleeding	Right hemiplegia, bradycardia , cardiac arrest recovered after cardiac massage and followed by complete arrhythmia
4	30	M	>70	12	>6	yes	FT	III	NA	I	No	Pulmonary edema
5	51	F	>70	12	>6	yes	FT	IV	6h	I	Massive bleeding	Left hemiparesis, hematoma,
6	52	F	>70	5	>6	yes	SF	IV	6h	II	Massive bleeding	hematoma
7	71	M	>70	3	8	yes	FT	II	6h30	I	No	meningitis
8	52	F	>70	5	>6	yes	SF	IV	NA	I	Massive bleeding	Hematoma , neurological deterioration
9	24	F	>70	6	4,96	yes	FT	IV	6h	I	Massive bleeding	Left hemiplegia+persistant cerebral herniation
10	47	F	>70	24	4,75	yes	FT	II	7h	III	No	Neurological deterioration, hematoma
11	6	F	<70	1 week	5,2	yes	FT	IV	8h	I	Massive bleeding	Pneumopathy, meningitis, extradural hematoma due to accident with Vit K
12	57	F	<70	6	5,68	Yes	FT	IV	NA	I	Massive bleeding	Hemiplegia

TABLE 33 MORTALITY IN OUR SERIES

5. Others:

Complication		Cases
Infections	Meningitis	6
	Pneumopathy	3
	Sepsis	1
	Empyema	2
	Others : Conjunctivitis and Orchi epididymitis	2
Phlebitis		1
Bilateral Frontal ischemia		1
Acute pulmonary edema		1
Diabetes insipidus		4
Electrolytic disorders		1
Fistula , Rhinorrhea		5

TABLE 34 POSTOPERATIVE COMPLICATIONS IN OUR SERIES

B. Long term results :

The good outcome after surgery is defined by a normal state of patient or the presence of minor sequelae allowing him/her to carry on normal activities . The Karnofsky Performance Scale Index allows patients to be classified as to their functional impairment. This can be used to compare effectiveness of different therapies and to assess the prognosis in individual patients. The lower the Karnofsky score, the worse the survival for most serious illnesses.

Able to carry on normal activity and to work, no special care needed	100	Normal with no complaints; no evidence of disease.
	90	Able to carry on normal activity; minor signs or symptoms of disease
	80	Normal activity with effort, some signs and symptoms of disease

Unable to work, able to live at home and care for most personal needs; varying amount of assistance needed	70	Case for self, unable to carry on normal activity or do active work
	60	Requires occasional assistance, but able to care for most of his/her personal needs
	50	Requires considerable assistance and frequent medical care.
Unable to care for self; requires equivalent of institutional or hospital care' disease may be progressing rapidly	40	Disabled; requires special care and assistance.
	30	Severely disabled; hospital admission is indicated although death is not imminent
	20	Very sick; hospital admission necessary, active supportive treatment necessary.
	10	Moribund; fatal processes progressing rapidly
	0	dead

TABLE 35 KARNOFSKY SCALE**1. Follow up results:**

Follow up results were gathered by reaching out to patients , either by phone calls or in person. 2 patients in our series committed suicide after a major depression, and one patient at 6 months after his second surgery for an aggressive recurrent meningioma.

The ranging extremes follow-up period was from one year and a half to 13 years, with a mean follow-up of 5 years:

➤ 6 months:

-KS <70% : 19 patients. KS >70%: 49 patients. Death: 1 patient

➤ 1 year:

-KS <70% : 19 patients. KS >70%: 49 patients. Death: 1 patient.

➤ 5 years:

-KS <70% : 10 patients. KS >70%: 44 patients.

➤ >5 years:

-KS <70% : 7 patients. KS >70%: 33 patients. Death: 1 patient.

2. Recurrence:

Recurrence is defined as clinical or neuroradiological evidence of disease progression, 12 died after surgery, one patient at 6 months, 2 others at 1 year and one patient at 5 years. Only 40 patients were contacted. Therefore 14 from 44 patients (31.18%) were observed with recurrence with a mean follow-up of 5 years, ranges (6month to 13 years).

Circumstances	
Clinical	5
Radiological	9

TABLE 36 ENCOUNTERED CIRCUMSTANCES IN RECURRENCE MENINGIOMAS

	Age	Sex	Delay	Location	Size cm	Simpson	Histology	Management
1	65	M	6months	SOMs	3	IV	I	Reoperated
2	41	M	6years	TSMs	3.46	IV	III	Follow up
3	53	M	2years	ACP	4.6	IV	II	Follow up
4	64	M	3years	CSMs	2.65	IV	I	Radiotherapy
5	37	F	6years	PSMs	2.1	II	I	Reoperated (insipidus diabetes)
6	32	F	5years	ACPs	3.3	IV	II	Follow up + radiotherapy
7	59	M	1year	PSMs	4	IV	I	Reoperated- died 2yrs
8	45	M	3months	OGMs	11	III	I	Reoperated
9	34	M	6months	PSMs	2,7	II	I	Follow up
10	46	F	7 years	SOMs	2,3	II	I	Will be operated
11	53	M	2 years	OGMs	3.3	II	I	Follow up
12	49	F	6 years	ACPs	8.1	II	I	Radiosurgery
13	36	F	3 years	ACPs	5.73	IV	I	Follow up
14	52	F	1 year	CSMs	3.8	IV	II	Radiosurgery

TABLE 37 PATIENTS WITH RECURRENCE MENINGIOMAS IN OUR SERIES

2.1. Age and gender :

Age : $P=0.36$: not significant

The mean age for skull base tumor recurrence was 48, 66 (range, 32 to 65) year,

Gender: $P=0.06$

The recurrence rate was 25% female $n=7$, versus 47% male $n=7$.

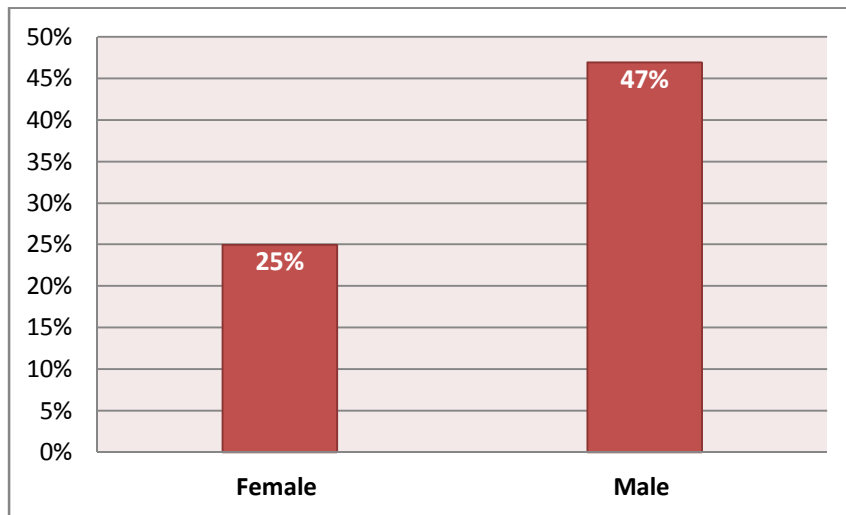


FIGURE 25 GENDER AND RECURRENCE

2.2. Recurrence delay :

The ranges were 6months to 6 years

2.3. Location: $P=0.6$

Location	Case (%)
Olfactory groove	2 (33)
Anterior clinoid process	4 (50)
Planum sphenoidale	4 (29)
Cavernous sinus	2 (67)
Sphenoorbital	2 (66)

TABLE 38 LOCATION AND RECURRENCE

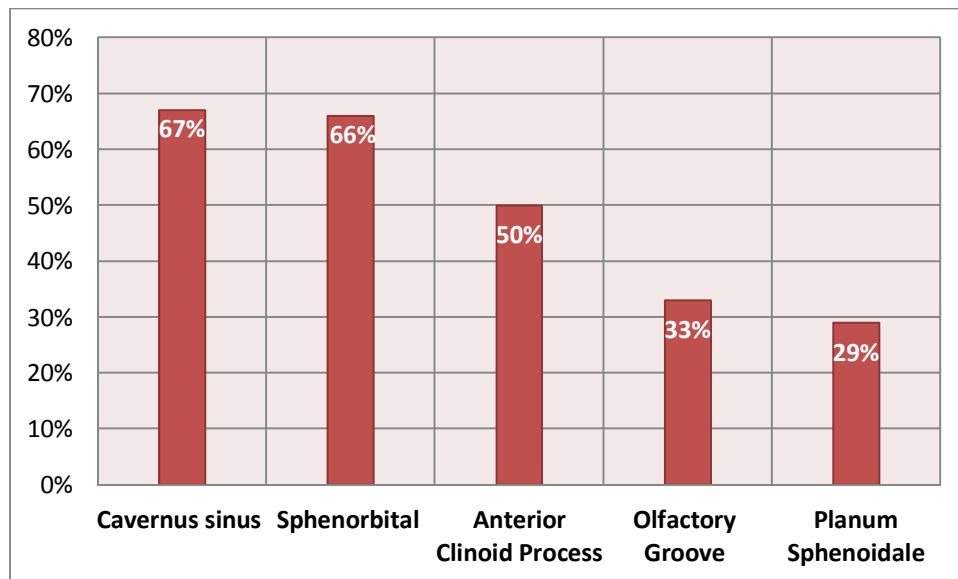


FIGURE 26 LOCATION AND RECURRENCE

2.4. Resection : $p=0.01$

Simpson grade	Case (%)
I	0 (0)
II	6 (20)
III	1 (50)
IV	7 (58)

TABLE 39 RESECTION AND RECURRENCE

2.5. Histopathology: $P=0.06$

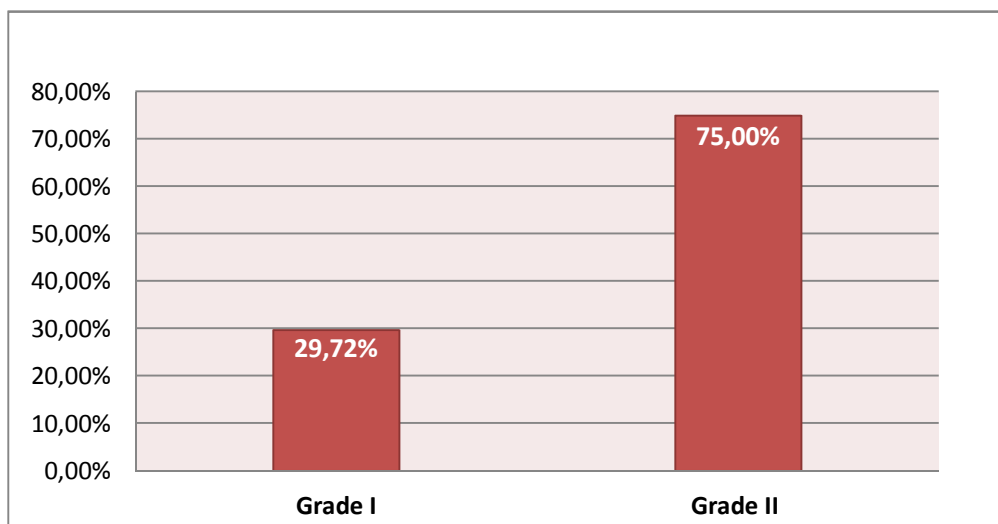


FIGURE 27 WHO GRADE AND RECURRENCE

2.6. Management :

During follow-up of the 14 "observed" patients having a recurrence of the tumor, 9 required intervention including surgical treatment in 5 patients , RT in 2 patients , and radiosurgery in 2 patients as well.

Conclusion:

In overall, gender, Simpson grade and pathology were the important factors associated with increased tumor progression in this study.

VIII. Prognosis :

On the basis of our experience with the previous works, we propose a new score-based classification system. given that we are investigating only in anterior and middle skull base meningiomas :

	Features	Cotation
Preoperative status	Karnofsky>70	0
	Karnofsky <70	1
Tumor size	[0,3]	0
	]3,4.5[	1
	>4.5	2
Perilesional edema	Absent	0
	Mild	1
	important	2
Location	Greater sphenoid wing Olfactory groove Orbital roof External and middle sphenoid wing	1
	Suprasellar Anterior clinoid process Sphenoorbital laterosellar	2
Pathology	I	0
	II	1
	III	2

TABLE 40 SUMMARY OF SCORING

Scores are the following:

- 0-3: class I
- 4-5: class II
- ≥ 6 : Class III

We reviewed the rating in all patients according to this classification, and we found that all patients class I were free of postoperative morbidity, however, in patients class II score, the rate of morbidity and mortality was higher 78% and 8% respectively. Complications were as follow: new cranial nerve deficit, diabetes insipidus, rhinorhea, hematoma, significant edema, language impairment.

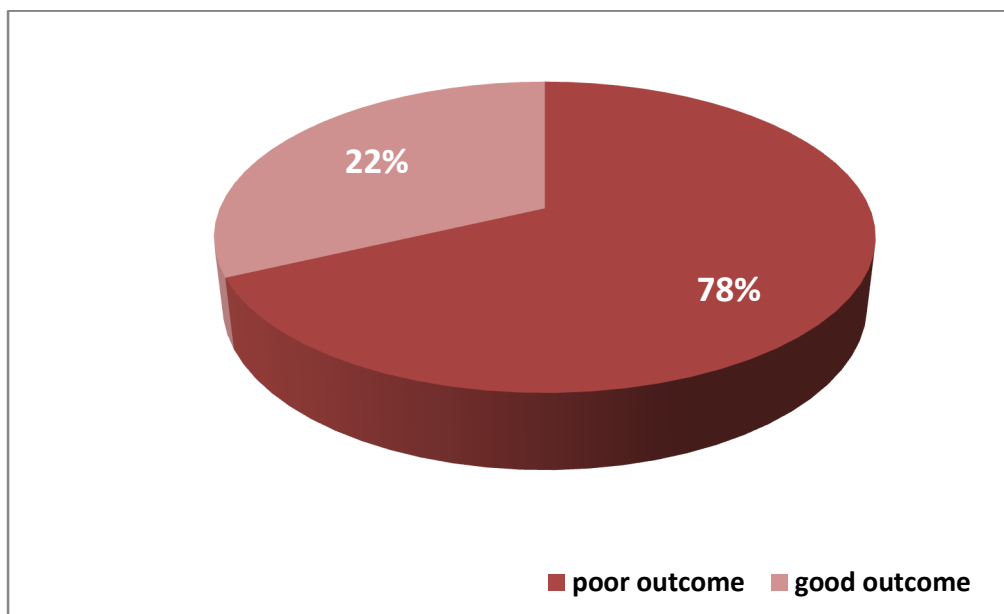


FIGURE 28 CLASS II SCORE

Lastly, all patients class III score died after surgery.

This is the suggested classification for anterior and middle fossa meningiomas:

Good prognosis	0-3 (CLASS I)
Medium prognosis	4-5 (CLASS II)
Poor prognosis	≥ 6 (CLASS III)

TABLE 41 PROGNOSIS COTATION



TABLE 42 ANTERIOR AND MIDDLE SKULL BASE MENINGIOMAS PROGNOSIS

DISCUSSION

I- HISTORY:

A. Before the Twentieth Century

Intracranial tumors we now call *meningiomas* existed before the start of recorded history. The oldest paleopathological evidence of a hyperostotic meningioma is a skull excavated in southwestern Germany estimated to be 365,000 years old,² and many additional specimens have been preserved from North and South America, Europe, and Africa [13]. However, before the advent of modern imaging, the presentation of meningiomas, as with other intracranial lesions, was an impenetrable mystery unless the tumor caused some external sign such as a hyperostotic mass. Clinical signs such as headaches, vomiting, visual changes, hemiparesis, and seizures certainly could have been observed but would not have been well enough understood to support a specific diagnosis. Indeed, many meningiomas are clinically silent, and only symptomatic cases would have come to medical attention before modern imaging.

The first documented attempts at surgical removal of extra axial convexity lesions, some of which were probably meningiomas, took place in the eighteenth century. It was during this time, in the final years of the French Enlightenment, that the French military surgeon Antoine Louis produced the first known scientific publication exclusively describing meningiomas.

Advances in pathology and physical diagnosis during the eighteenth and nineteenth centuries, especially in France, made it possible to correlate histories, symptoms, and physical examination findings during life with autopsy findings. Jean Cruveilhier's *Anatomie pathologique du corps humain* (published 1829–1842) included detailed illustrations of meningiomas, accurately describing their typical locations as the convexities, petrous bone, olfactory groove, middle fossa, tentorium, and falx, and correlating them with symptoms and physical findings. [14]

At least, in theory, these advances laid the groundwork for diagnosing such a tumor by neurological examination alone. It would be several decades before this was actually achieved, but during the nineteenth century several successful operations for dural-based

tumors with overlying. hyperostoses or palpable masses were performed, by Pecchioli in 1835, [15] by Macewen in 1881, and most famously in 1885 by Francesco Durante, a professor of surgery in Rome who successfully diagnosed and removed a left olfactory groove meningioma. [16] [17]

B. The early twentieth century : before Cushing:

By the beginning of the twentieth century, the three necessary ingredients for minimally successful brain surgery were firmly in hand. Anesthesia had been available since the late 1840s, Lister's antiseptic methods since the 1860s, and Ferrier's advances in cerebral localization since 1876. But not until ~1910 would the next important technical advances in brain surgery become available— Cushing's hemostatic methods and his understanding and early control of intracranial pressure. During this interval it became increasingly possible to localize many enlarging intracranial mass lesions, Surgeons were willing to operate despite the dangers, because of the known dismal natural history under medical treatment alone. But early mortality rates were very high. In reaction to this situation, some neurologists and surgeons attempted to specify "requisites for operability" for brain tumors, and then to use autopsy data to define the percentage of brain tumor patients who might conceivably benefit from the operation. Ernst von Bergmann specified that a truly operable tumor must be not too large, not metastatic, not multiple, encapsulated and exposed on the surface of the convexity. [18] Using similar criteria, Starr estimated in 1893 that ~7% of brain tumors were operable. [19]. In 1905 Walton and Paul classified only 3.3% of 424 tumor cases as definitely operable—"primary, accessible, well- defined tumors which may be removed without cutting into brain tissue . . . [with] distinctive symptoms.", these criteria essentially limit the field of "operable tumors" to convexity meningiomas, but this diagnostic entity had not yet been defined.

For Keen, at age 50 one of America's leading surgeons, it had been his "very first modern brain operation. . . my heart 'sank down into my boots.' But dangerous as the procedure might be I had to go ahead." Harvey Cushing, at the end of his own career, wrote that Keen's "vivid account" should be read "by every beginner who may . . . feel trepidation at the task ahead of him." [7]

C. Cushing's Contributions

By 1906, Horsley considered that “all tumors which, growing from the meninges, penetrate the brain, or which are encapsulated, can all be excised with a good permanent result.” [20] Cushing, before having a single personal case of meningioma, wrote in 1908 that they “offer[ed] the most favorable type of tumor for operation.” [21] The challenge was clearly framed: successful complete excision might represent a cure if the patient could only survive the surgery.

The cumulative contributions of one neurosurgeon, Harvey Cushing, over his career stand alone in their significance for the safe and successful surgical management of meningiomas. Cushing's 1938 monograph *Meningiomas: Their Classification, Regional Behavior, Life History, and Surgical End Results* describes in great detail 313 patients who underwent surgical treatment of their meningiomas between 1903 and 1932 [7]. Just as successful diagnosis and appropriate surgical exposure were crucial obstacles to successful surgical resection of meningiomas before the twentieth century, the next great hurdle to be overcome was achieving adequate hemostasis. Due to the possibility of severe and often fatal blood loss, as well as the inadequacy of anesthesia, most cranial operations before the twentieth century were shockingly brief by today's standards—less than an hour in many cases. Cushing demonstrated an acute recognition of the importance of hemostasis and was a careful, meticulous, even slow surgeon by the standards of the time. [22; 23] . In his words, “More operative fatalities have been due to exsanguination and its consequences than all other causes combined.” This was especially true of meningiomas, due to their frequent vascularity and proximity to the dural venous sinuses. Dandy, a fearless surgeon who was technically without peer, felt that meningiomas “offer[ed] the most difficult battles in cranial surgery.” [24].

Cushing's contributions are notable not only for innovations in surgical technique but also for exhaustive attention to detail, particularly with respect to the clinical examination. In collaboration with his assistant Louise Eisenhardt, he conducted detailed follow-up on his patients, slowly amassing invaluable data on the long-term outcomes of his cases.

D. Mid- to Late-Twentieth Century

In its general principles, surgical removal of meningiomas has changed less in the decades since Cushing than it did during his career. Meningioma surgery still involves devascularization of the tumor mass, internal debulking, and maximal safe removal, including the dural attachment where possible. Many incremental technical innovations, such as the pneumatic drill, [25; 26] bipolar cautery, [27] and the operating microscope [28] and endoscope [29], have made procedures progressively easier for the surgeon and safer for the patient. Few of these innovations are used exclusively for meningioma surgery, and most are described more extensively in works on general neurosurgical history [30].

II- EPIDEMIOLOGY

A. Risk factors:

1. Ionizing Radiation

At present, the primary environmental risk factor identified for meningioma is exposure to ionizing radiation (IR), with risks from 6- to 10-fold reported. 6–10 At high dose levels, Radio-induced meningiomas can be divided into two major groups according to irradiation doses received: low doses (less than 10 GY) or high doses (Greater than 20 GY). data exist for atomic bomb survivors [31] and show a greatly increased risk for meningioma, with increasing risk correlating with the proximity to the epicenter of the explosion. Black ET coll et Jan , In one of their most well-known studies to date of IR and meningioma risk, children who were given radiation therapy for scalp ringworm in Israel between 1948 and 1960 (the TineaCapitis Cohort) were observed to have a relative risk of almost 10 for meningioma, The latency of onset is high between 20 and 35 years [32]. Meningiomas occur after high doses of irradiation has been reported mainly after radiotherapy for adenoma of the pituitary gland and Medulloblastoma, which may explain the young age of these patients by General population. The latency of onset is shorter, between 12 and 25 years [32].

Several studies have linked the number of full-mouth dental radiographs to risk of meningioma, although the sample sizes are limited, and most later studies (also small in size)

did not confirm these findings. The most recent case control study of 200 meningioma patients reported that the full-mouth series was associated with a significantly increased risk of, although evidence for a dose response relation was lacking [33]. Radiation therapy for intracranial tumors has also been linked to meningioma risk, [32] and animal studies support the contention that IR can induce intracranial tumors, including meningiomas, by damaging DNA, with resultant single-strand or double-strand breaks. No recent large-scale studies of meningioma risk relative to IR exist, when x-ray doses for dental and other procedures have decreased but during which time new radiographic procedures have been introduced, including computed tomography (CT).

In our series, no radiation-induced meningioma was detected, as none of our patients had received radiotherapy in the scalp beforehand.

2. Hormones

An association between hormones and meningioma risk has been suggested by several findings, including the increased incidence of the disease in women versus men (2:1); the presence of estrogen, progesterone, and androgen receptors on some meningiomas; an association between breast cancer and meningiomas; indications that meningiomas change in size during the luteal phase of the menstrual cycle and pregnancy; and in vitro proliferation of meningioma-cell lines in culture after exposure to estrogens has been observed [34].

A pilot study of 31 meningioma samples reported that gene expression appeared more strongly associated with progesterone receptor (PR) status than with estrogen receptor (ER) status.¹¹ Genes on the long arm of chromosome 22 and near the *NF2* gene (22q12) were most frequently noted to have expression variation, with significant upregulation in PR+ versus PR– lesions suggesting a higher rate of 22q loss in PR– lesions. Researchers have only begun to address the question of whether the use of exogenous hormones such as oral contraceptives and/or hormone replacement therapy is associated with an increased risk of meningioma [35; 36; 37] .

Progesterone Receptors (PR):

Over the past two decades, a considerable amount of work has demonstrated the presence of progesterone receptors at biologically active levels within meningiomas [38] [39] [40] [41].

However, in the vast majority of cases, the presence of these receptors has never been able to establish clear relationships between their level, age, sex, and hormonal status in women. Schrell [40], find that progesterone receptors are mostly absent in the nucleus, and concludes that cytosolic receptors are present only in an inactive form and that Fact; they can play no role in the growth of meningiomas and cannot be considered as tumor markers. This implies that antiprogesterone treatments can, therefore, have no effect. The only correlation that is found more consistently between the presence of hormone receptors and a characteristic of the meningioma concerns the histology. Several authors have found their presence in benign meningiomas and their absence in atypical or malignant meningiomas, which means that the progesterone receptors are a factor of good prognosis. [42] [43].

Estrogen receptors (ER):

Although early receptor studies have been successful in the detection of estrogen receptors, the validity of the assay methods used (binding to a high-affinity radioligand) has not been sufficiently verified to be of real value [44]. Recent immunological techniques confirm that there are no biochemically detectable estrogen receptors in meningiomas.

Other receptors:

Androgen receptors have also been found in a large number of meningiomas but it is only since the use of modern detection techniques (Northern blots and in situ hybridization) that the messenger RNA of These receptors, implying that they can play a role in their growth [45]. As in many other intracranial tumors, glucocorticoid receptors have been found, but they cannot be said to mediate the action of glucocorticoids on peritumoral edema.

In our series, we believe that sex hormones had a significant role in 9 patients. A patient with a meningioma had been operated on for breast cancer. According to Schoenberg et al [46], the association of breast cancer meningioma appears to be statistically significant (a woman with

breast cancer has a high risk of developing a meningioma compared to the general population). More details about for breast cancer will be described in the next chapter.

Another patient with a greater sphenoid wing meningioma was 6 months pregnant, the particularity in her is the amplification of neurological symptoms due probably to the high progesterone concentration.

3. Association with Breast Cancer

An association between breast cancer and meningioma has been examined in several studies [35] [47] [48]. Several explanations have been proposed for this association, including the presence of common risk factors, such as endogenous and exogenous hormones as well as shared genetic predisposition, including variants in DNA repair polymorphisms. [47] Custer et al provide a review of the literature and an analysis of the association between breast cancer and meningioma using the western Washington State cancer registry data [49]. The relative risks observed across existing studies range between 1.5 and 2.0, with the majority statistically significant.

Most of these studies have been conducted with tumor registry data and have relatively small sample sizes, and none has been able to examine the association while controlling for risk factors that are likely to be shared by the two tumors, such as pregnancy and menstrual variables and exogenous hormone use. Intriguing new data gathered from an analysis of five of the case-control series from the Interphone Study report suggest that variation in the breast cancer susceptibility gene 1 (*BRCA1*)-interacting protein 1 (*BRIPI*) is associated with meningioma risk [47].

4. Head Trauma

Since the time of Harvey Cushing, head trauma has been suggested as a risk factor for meningioma, although the results across studies are not consistent. several small case-control studies from the early 1980s report an increased risk of meningioma associated with head trauma for both males and females, other studies report no such association.

A cohort study of 228,055 Danish residents hospitalized for concussion, skull fracture or other head injuries between 1977 and 1992 did not find any significant increase in the incidence of meningioma, although the mean follow-up was only 8 years [50].

In our series, 2 patients had a past history of head trauma, however, it cannot be asserted that it is the cause of developing the tumor, as stated in the Annegers study [51].

5. Cell Phone Use

The question of whether cell phone use is related to meningioma risk remains of great interest to the general public. At least 10 studies have examined the association between cell phone use and brain tumor. At present, little evidence exists for an association between the two, although sample sizes specific to meningiomas are relatively small, the follow-up time since the commencement of cell phone use relatively short, and, in some instances, the measurement of cell phone use somewhat crude [52] [53].

6. Industry/Occupation/Diet/Allergy

Attempts to link specific chemicals with meningiomas in occupationally or industrially exposed groups have proved inconclusive [34; 49]. A recent international case-control study found no association between diet and meningioma ($n = 332$) [49]. Although several studies that examine the relationship between glial brain tumors and allergic disease such as asthma and eczema have found evidence for an association, little evidence has been found for such an association for meningioma [54].

For our series, only 3 patients had allergic disease as asthma.

7. Family History of Meningioma

Few studies have examined the relationship between meningioma risk and a family history of meningioma. Malmer et al [55] examined cancer risk in spouses and first-degree relatives of brain tumor patients in Sweden and reported that a meningioma diagnosis conferred a twofold increase in meningioma risk to first-degree relatives (SIR: 2.2, 95% CI: 1.4 to 3.1) but not to spouses of affected individuals. An inverse association between risk and

age at onset was appreciated, with an SIR of 2.5 (95% CI: 1.5 to 4.0) for probands under 50 years of age versus 1.3, (95% CI: 0.6 to 2.6) for probands older than 50 years of age. Similar analyses by Hemminki et al [26] using data from the Swedish and Norwegian Registry

Databases reveal an increased risk with increasing numbers of affected first-degree relatives with persons having one or two first-degree family members with meningioma (SIR: 1.6, 95% CI: 1.3 to 42.0 and SIR: 5.0, 95% CI: 0.9 to 14.8, respectively). Despite the fact that up to 1% of the adult population may harbor a meningioma [56], the total number of families with multiple members diagnosed with meningioma is relatively small (indicating, in part, a wide spectrum of phenotypic expression with respect to clinical import and hence screening undertaken), and most such families are currently attributed to inherited *NF2* mutations. At the present study, no family-based linkage or segregation analyses studies of meningioma have been reported.

8. Genetic Polymorphisms

8.1. Chromosome 22 and the NF2 Gene:

Meningiomas are the first solid neoplasms to be identified with a characteristic cytogenetic alteration [57; 58]. Monosomy 22 is the most frequent genetic abnormality found in meningiomas. This association between the long arm of chromosome 22 (22q) and meningiomas was first studied in patients with NF2. Patients with NF2, a dominantly inherited disorder, commonly present with bilateral vestibular schwannomas, multiple meningiomas, and other nervous system tumors. Roughly 50% of meningiomas have allelic losses in 22q12.2 [59], a region encoding the *NF2* gene. Nearly all NF2-associated meningiomas, and 54%–78% of sporadic meningiomas, have deletions in this region. [57].

8.2. DAL-1:

Merlin's role in meningioma tumorigenesis led to several studies of the structurally homologous and functionally similar protein 4.1 family. A number of studies have implicated protein 4.1B as a potential tumor suppressor in meningiomas [60]. The *EPB41L3* or *DAL1* gene is located at 18p11.3 and encodes protein 4.1B, a regulator

of proliferation and apoptosis [61]. Like merlin, protein 4.1B contains 3 functional regions, including a highly conserved amino-terminal FERM domain (protein 4.1 and ERM binding), a spectrin-actin binding domain, and a carboxy-terminal domain. Each domain is separated by a unique interspersed region, termed U1, U2, and U3. Differentially expressed in adenocarcinoma of the lung-1 (DAL-1) is a smaller protein fragment of protein 4.1B that retains a tumor suppressive property identical to that of protein 4.1B [60]. Protein 4.1B loss has been demonstrated in meningiomas at the DNA level through in situ hybridization, at the RNA level through reverse transcription–polymerase chain reaction, and at the protein level through Western blot and immunohistochemical analyses [62]. These studies reported that reexpression of protein 4.1B/DAL-1 suppressed meningioma cell growth while genetic analysis of losses on chromosome 22 has provided a foundation for understanding meningioma pathogenesis, the previously discussed genetic alterations constitute early events in meningioma development [59; 63; 58]. Benign meningiomas rarely have chromosomal aberrations beyond chromosome 22 losses. More complex karyotypes are associated with more aggressive meningioma behavior [59]. Malignant progression, thought to follow the theory of clonal evolution, is associated with a stepwise cumulative acquisition of chromosomal gains and losses, leading to more aggressive subclones with greater growth advantage [64; 65; 66]. Atypical and anaplastic meningiomas exhibit much more complex genetic changes than their benign counterparts, with losses on 1p, 10q, 14q, and less frequent losses on 6q and 18q. Higher grades are also associated with chromosomal gains on 1q, 9q, 12q, 15q, 17q, and 20q [59; 63]. In addition to these genetic changes, anaplastic meningiomas exhibit more frequent losses on 6q, 10q, 14q, and 9p, with amplification on 17q23 (**See fig 29**) [67; 68; 58; 65; 69]. Epigenetic alterations, including increased CpG island hypermethylation, have also been associated with malignant meningioma progression.

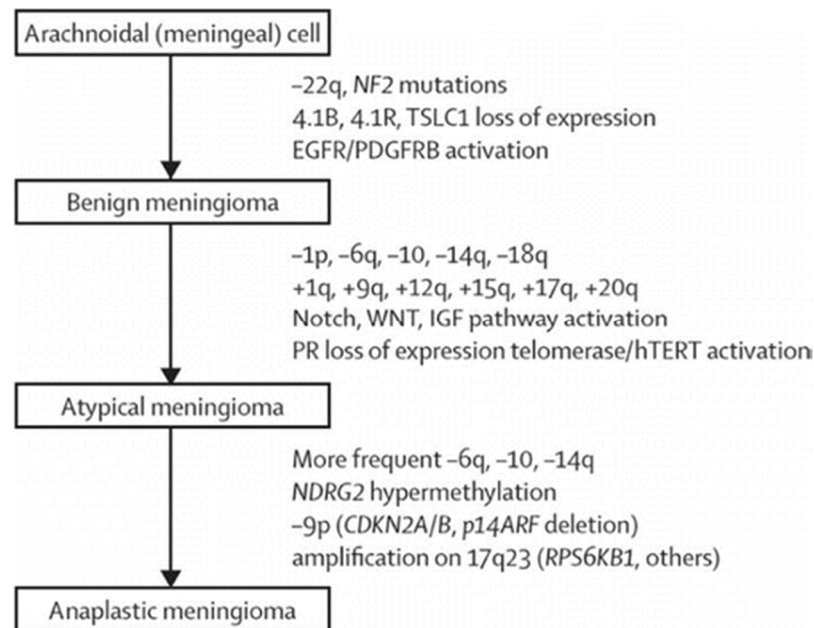


FIGURE 29 THE GENETIC ALTERATIONS UNDERLYING MENINGIOMA FORMATION AND PROGRESSION. [70]

Meningiomas are thought to arise from arachnoidal cells. Losses of 22q and other family 4.1 proteins represent early events in meningioma formation. Higher grade meningiomas are associated with more complex karyotypes, and progression is characterized by the accumulation of chromosomal losses and gains. Loss of 9p is characteristic of anaplastic meningiomas.

Conclusion:

The study of risk factors for intracranial meningioma remains a challenging and largely unexplored field. The known risk factors of genetic predisposition and high dose radiation exposures account for a small proportion of cases. Although a role for hormones is likely given the gender distribution of meningiomas, few specific or consistent data exist on hormonal risk factors. Tools from epidemiology may be used to collect and define appropriate subject data from well-defined source populations to define risk factors for the overall group of meningioma patients as well as for specific subgroups.

Multicenter efforts between a variety of researchers will be needed, including experts from such fields as neurosurgery, epidemiology, genetics, statistics, and neuropathology.

Hospital-based brain tumor series indicate that the incidence of meningiomas is approximately 20% of all intracranial tumors.

100 patients harboring anterior and middle fossa meningiomas were identified in a set of 465 of intracranial meningioma.

Authors	Frequency
DESGEORGES ET COLL [71]	22%
PHILIPPON [72]	26%
JAN ET COLL [73]	37,4%
ALAWANE SINDOU [74]	41%
OUR SERIES (anterior and middle fossa)	17,4%

TABLE 43 SKULL BASE MENINGIOMAS REPORTED IN LITERATURE

C. Age and gender :

The most common age group of meningiomas is usually between 20 and 60 years, with a peak at the fifth decade [75] which concurred with our findings.

Feminine predominance is very classical. This prevalence in women is explained in part by the presence of progesterone receptors (PR) in these tumors. However, this hypothesis of hormonal stimulation in women remains unclear, because it has found that some meningiomas occurring in men and children might also express PR. The reported series in literature identify a female predominance of meningiomas especially in adult patients [76].

Meningiomas are uncommon in the pediatric age, accounting for 0.4 - 4% of all cerebral tumors in this age group and for 1.5% of all intracranial meningiomas. Anterior and middle fossa meningiomas were the most common region affected in children in a series of 199 cases (50 cases; 7.2% overall) [77].

Whereas intracranial tumors show a higher prevalence in males than in females, meningiomas have a 2: 1 female-to-male ratio [78]. However, this proportion might vary according to Pathology, obvious male predominance were found in atypical and anaplastic meningiomas [79].

Of interest is that the Manitoba meningioma study showed no increased prevalence in women

aged up to the fourth decade, as well as a readjustment to an almost 1:1 ratio after the sixth decade [77].

III- Clinical presentation:

Clinical presentation depends on the localization of meningioma, the size, and the evolution duration. [80].

A. Anterior fossa:

1. Olfactory groove:

Olfactory groove meningiomas (OGMs) account for ~9 to 18% of all meningiomas [81]. For our series, it accounts for 14 % of the skull base meningioma, anterior and middle fossa.

OGMs arise from the region of the frontosphenoid suture and may involve any part of the area from the crista galli to the planum sphenoidale (**See fig 30**). Anterior, middle, and posterior. OGMs have been described, but subclassification into these subtypes is rarely useful, and the site of origin may be uncertain when they are large and extend back to the pituitary fossa (**See fig. 31**) Meningiomas that occur in the region of the olfactory groove are often symmetric and midline, but they can also be located eccentric to one side. The tumors can be associated with hyperostosis in the skull base. They can also thin or destroy the bone, leading to tumor invasion of the sinuses and, rarely, the orbits. With small tumors, the olfactory nerves can be preserved on one side as they lie on the lateral aspect of the tumor. With larger tumors, however, the nerves are thinned to such a degree that their preservation is almost impossible [81].

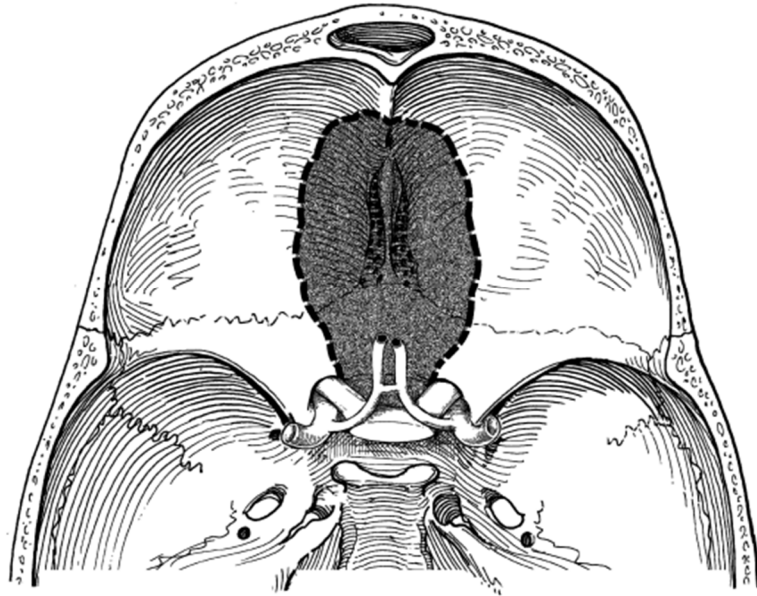


FIGURE 30 ILLUSTRATION OF THE OGMS IN THE BONY BASE OF THE SKULL. [82]

The shaded area is the common site of tumors arising from the region of the olfactory groove. Note the relation of the optic chiasm and the anterior cerebral arteries.

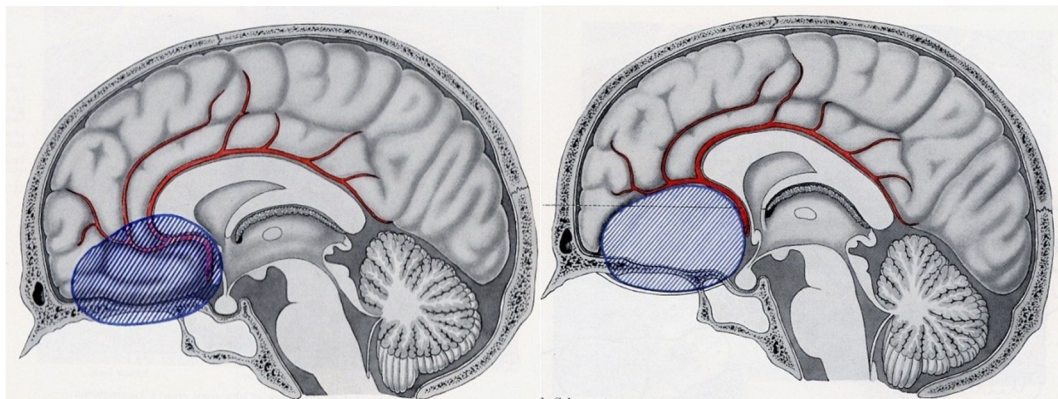


FIGURE 31 PROJECTION OF OLFACTORY GROOVE MENINGIOMA (IN BLUE). [82]

Displacement of cerebral structures by OGMs (in blue), especially the anterior cerebral artery and its branches.

Clinical features:

Due to their slow growth and subfrontal location, and because of the ability of the cerebral tissue to adapt to slow compression and the relative lack of focal functional cortical

regions in the adjacent cerebral tissue, OGMs present insidiously, and they can often grow large before causing symptoms, in our series 9 of 14 tumors were large (64.28%) (More than 3cm and usually over 4cm) One of the most common symptoms is:

- Headaches, n=13(92.85%) and intracranial hypertension found in n=12(85.71%) patients at the admission.

The second common symptom is that of:

- A change in personality, judgment, or motivation noted by family members or close contacts, but not usually by the patient. 5 patients from our series had a change in personality as queerness, 3 patients had memory disorder and 2 were complaining from concentration disorder.

Because of the growth pattern of OGMs and their effect on the regional anatomy, these tumors may extend posteriorly and inferiorly to compress the optic nerves and cause an inferior visual field defect, but this may be difficult to detect in patients with large tumors who are apathetic and who may have papilledema. , Then can include:

- Visual disturbances occurring only late in the course of the disease when the lesion grow to a very large size before diagnosis. In our series 11 patients presented with visual impairments at the admission (78.57%); the size of these tumors was superior to 4cm. 2 of these patients had blindness at both eyes (14.28%). (Size of tumor in these 2 patients was 11cm and 5cm), while 6 patients had preblindness at both eyes (42.85%).

Although the Foster-Kennedy syndrome of unilateral optic atrophy and contralateral papilledema was initially described in a midline frontal meningioma and in 24% of Cushing's cases, it is only rarely seen in modern series [7] (which corresponds with our findings, no foster-Kennedy syndrome for olfactory groove was identified in this serie) .

Another symptom which can be present in OGMs is:

- Anosmia: n=2 (14.28%) have consulted for anosmia, however 8 (57.14%) Patients were found with anosmia and hyposmia on the physical examination.

Thus, we can presume that Anosmia had not been an important symptom. Cushing reported that loss of the sense of smell was possibly primary symptom in only 3 of his 29 patients, and he questioned the reliability of the records in this regard. In Bakay's [83] series,

all symptomatic patients had anosmia on examination. But in none was it a symptom that led to the diagnosis. He noted that patients are not usually concerned when they gradually lose their sense of smell over a long period of time. In the series of Robert G. Ojemann, one patient recorded on questioning that loss of sense of smell was the first symptom. Then, we could presume that Patients rarely complain of altered smell or taste,

Most patients with OGMs are women in the fifth and sixth decades of life.

Authors	Year	Nb of patients	Mean age	Sex M:F	H/A	Mental Change (%)	Visual Loss (%)	Hyposmia / Anosmia (%)
Cushing	1938	29	43 (29–62)	NA	12 (41)	6 (21)	11 (38)	3 (10)
Bakay	1984	36	55(NA)	15:29	18 (50)	16 (44)	17 (47)	26 (72)
Spektor	2005	80	55 (16–85)	21:59	41 (51)	21 (26)	22 (28)	39 (49)
Ojemann	2006	17	NA (24–73)	5:14	3 (18)	9 (53)	7 (41)	1 (6)
Bassiouni	2007	56	51 30–74	15:41	11 (20)	22 (39)	9 (16)	8 (14)
Nakamura	2007	82	58 (33–91)	19:63	26 (32)	59 (72)	20 (24)	48 (59)
Aguiar	2009	21	50 (21–76)	6:15	12 (57)	4 (19)	4 (19)	21 (100)
our series	2017	14	47 (21-65)	5 :9	13(93)	6(43)	11(79)	2 (14)

TABLE 44 CLINICAL FEATURES OF OGMS REPORTED IN LITERATURE [81]

2. Orbital roof:

Very few articles were found about the orbital roof meningiomas. They are very rare tumors, 2 of 100 patients had orbital roof meningiomas (2%) in our series. Patients had

- Headaches at the admission,
- Behavior and memory disorder
- Seizures

In addition to these symptoms mentioned, 1 patient has :

- Decreased vision
- Anosmia

B. Middle fossa:

1. Suprasellar meningiomas:

Suprasellar meningiomas usually arise in the midline from the region of the tuberculum sellae and planum sphenoidale, but they can arise from the diaphragm sellae, or be located primarily to one side, arising from the anterior clinoid region.

1.1. Planum sphenoidale :

Planum sphenoidale meningiomas occur along the anterior cranial base overlying the area of the planum sphenoidale. These tumors are usually bilateral based on their midline origin, although they can also be unilateral.

Clinical features:

Planum sphenoidale meningiomas are closely related to tumors of the tuberculum sellae, but their clinical presentations and surgical outcomes are very different. Given their proximity to the optic chiasm, tuberculum sellae tumors manifest early, Visual deficits are present even when the lesions are small. Given the paucity of symptoms associated with small tumors, early diagnosis of olfactory groove and planum sphenoidale meningiomas continues to be a problem. However, since the advent of cranial imaging with computed tomography (CT) and magnetic resonance imaging (MRI), these lesions are being identified earlier and at smaller sizes. Given their location and slow growth, planum sphenoidale meningiomas often obtain a significant size before they become symptomatic as is noticed for the olfactory groove meningiomas. In series reported by Hentschel and DeMonte [84] and by Turazzi et al. [85] more than 50% of patients had tumors larger than 6 cm.

Most patients develop one or a combination of the following symptoms:

- Subtle mental changes in cognition and personality with concentration disorder n=10 (29.41%),
- Headaches n=26 (76.47%),
- Visual decline n=27 (79.41%), (6 patients with monocular blindness and 21 with monocular preblindness) . 5 patients from 27 had these two visual impairments at the same time, namely, a blindness at one eye and preblindness at the other eye.

- Foster Kennedy syndrome was found in 2 patients in our series.
- Seizures n=4 (11.76%).

The onset of these symptoms is usually gradual and most often appreciated first by close family members. Visual loss is usually limited to changes in acuity and restriction of the inferior fields. The visual symptoms associated with a planum sphenoidale meningioma often appear earlier than those associated with an olfactory groove meningioma because the former is closer to the optic apparatus than the latter. The visual loss is often more severe in one eye, but both are commonly involved.

We notice that planum sphenoidale doesn't differ from OGMs concerning the symptoms.

Localization	Decreased Visual acuity cases/%
Olfactory groove	11 cases/78.57%
Planum sphenoidale	27 cases/ 79.41

TABLE 45 DECREASED VISION ON BOTH OGMs AND PSMS IN OUR SERIES

The vision impairment seen in OGMs can be explained by their large size.

1.2.Tuberculum sellae:

Tuberculum sellae meningiomas (TSMs) represent a small percentage of surgical case series and arise from the region of the chiasmatic sulcus and tuberculum, usually with a point of origin at the junction of the optic canal and lateral aspect of the chiasmatic sulcus. They comprise approximately 3%–10% of all intracranial meningiomas [84], they account for 5% of all skull base meningiomas, anterior and middle fossa. Correct diagnosis and management require an appreciation of the unique clinical, neuroimaging, and surgery-related features that distinguish these meningiomas from others of the anterior or middle skull base. Tuberculum sellae meningiomas characteristically lie in a suprasellar subchiasmal midline position, displacing the optic chiasm posteriorly and slightly superiorly, and the optic nerves laterally [84].

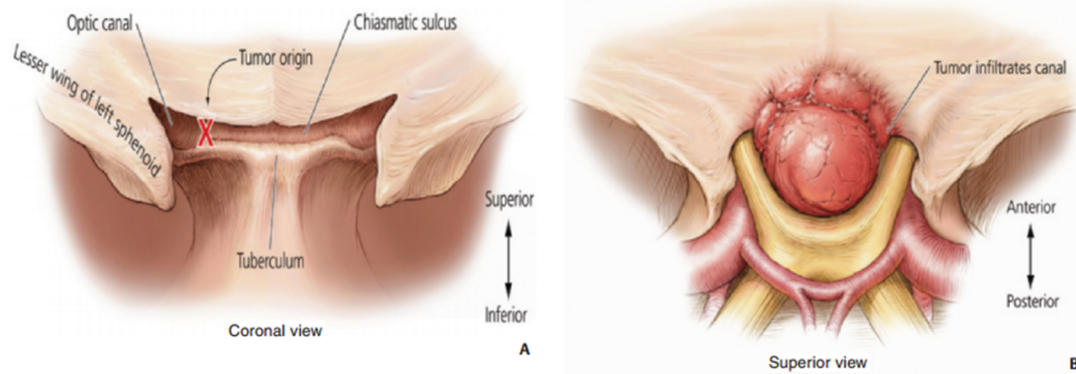


FIGURE 32 SCHEMATIC DIAGRAM DEMONSTRATING TSMS. [88]

The site of origin (A) and anatomical characteristics of TSMs (B).

Clinical features:

The most common problem in patients harboring tuberculum sellae meningiomas is:

➤ Visual deterioration, all the patients of our series have presented with a decreased vision. Patients with TSMs typically present with a history of uni- or bilateral visual decline progressing over months to years. Visual deterioration seems to be present early and often begins unilaterally, however in our series, 4 patients from 5 had a bilateral preblindness and this could be explained by the fact their growth is slow and insidious in most cases, therefore, the evaluation and diagnosis are typically delayed, and significant vision loss of one or both eyes occurs. As such, pre- and postoperative ophthalmological evaluation for both visual acuity and visual fields is mandatory. If evaluation is delayed tumors can grow and cause optic chiasm compression. On examination, more than 95% of patients suffer visual acuity and/or field deficits and approximately 75 to 90% have optic atrophy [86; 87; 88; 89]. The same finding was obtained in our series from the fundus examination, allowing to identify the optic atrophy as the most common result. The pattern of vision loss can vary, and although a bitemporal hemianopsia has been described as the most frequent field cut observed [86; 88].

Due to inferior compression of the optic nerves and chiasm by tuberculum sellae meningiomas which leads to unilateral or bilateral decreased acuity and often to incongruous visual field defects, this has not been corroborated in recent series. Quadrantanopsia and

unilateral temporal field defects are commonly reported in patients who have undergone formal ophthalmological visual field testing [87; 90].

- Headache is the second most common associated symptom occurring in approximately 35 to 45% of patients (100% in our series) and it may occasionally be the only presenting symptom [91; 92].
- Altered mental status, seizures, endocrinopathies, and anosmia have all been reported in association with tuberculum sellae meningiomas but are exceedingly rare. [91; 92]. None of these symptoms was founded in our patients. Evidence of endocrinopathies at presentation is present in only a small number of patients. Reduced libido, alteration in menses, and elevated prolactinemia are found in 5 to 10% of patients, but clear evidence of endocrinopathies should suggest a diagnosis of pituitary adenoma rather than meningioma [93].
- Unilateral weakness has also been reported, usually in the presence of significant frontal lobe edema, and bilateral frontal lobe involvement can manifest with disinhibition and behavioral changes.
- Nerve deficit was found in one patient in our series, touching the III nerve. This could be explained by the importance of perilesional edema found in the same patient.

Authors	Year	Nb of patients	Mean age	Sex M:F Or F:M Ratio†	Visual disturbance %
Nakamura et al.,	2006	108	54.3	55; 17	72 (100)
Fahlbusch & Schott,	2002	47	54.3/	4.1	96
Chi & McDermott,	2003	21	52.3/	2	90
Schick & Hassler,	2005	53	52.6/	3.1	83
Bassiouni et al.,	2006	62	53/	4	87.1
Ganna et al.,	2009	24	53.8/	5.1	100
Terasaka et al.,	2011	9	64.4/	8	100
Current series	2016	5	44	4.1	100

TABLE 46 CLINICAL FEATURES OF TSMS REPORTED IN LITTERATURE

1.3. Diaphragma sellae:

Preoperative differentiation between tuberculum and diaphragma sellae meningiomas may be difficult to make based on clinical features or neuroimaging findings, and diagnosis is made intraoperatively when dural attachment to the diaphragma is visualized. Tuberculum sellae (TS) and diaphragma sellae (DS) meningiomas represent 5–10% of all intracranial meningiomas [94; 95].

They are traditionally grouped together with other suprasellar meningiomas including the more anterior planum sphenoidale (PS) meningiomas. [95; 96]. TS meningiomas are more common than DS meningiomas [97; 98; 99], in a series of 67 suprasellar meningiomas, 25 were classified as TS meningiomas and only one as a DS meningioma [98]. However, in our series of 43 suprasellar meningiomas, 5 were TS meningiomas and 3 were having DS meningioma based on the intraoperative findings.

On the basis of an experience with 12 patients with diaphragma sellae meningiomas [100], these tumors were classified into three groups:

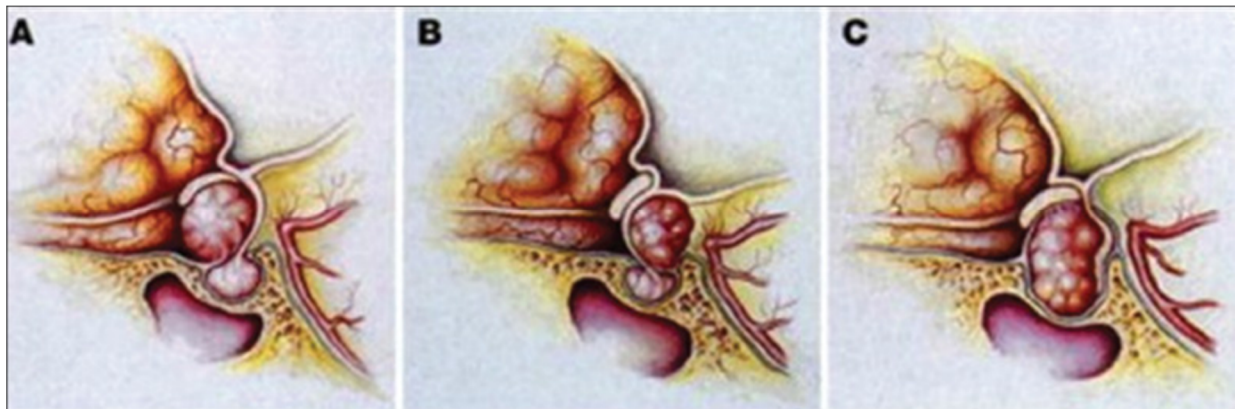


TABLE 47 THREE TYPES OF DIAPHRAGMA SELLAE MENINGIOMAS [70]

- ❖ Type A, originating from the upper leaf of the diaphragma sellae anterior to the pituitary stalk;
- ❖ Type B, originating from the upper leaf of the diaphragma sellae posterior to the pituitary stalk;
- ❖ Type C, originating from the inferior leaf of the diaphragma sellae.

Clinical features:

Each type of DS meningioma has specific clinical symptoms.

Type A mainly presents with:

- Unilateral visual disturbances and visual field defects resembling those of tuberculum sellae meningiomas, although preoperative diabetes insipidus occurred in patients with large tumors.

Type B causes:

- Fewer visual disturbances, but memory disturbance and hypopituitarism occur.

Type C closely resembles:

- Nonfunctioning pituitary adenomas; bitemporal hemianopsia and hypopituitarism are common.

Multiplanar magnetic resonance images can accurately diagnose the tumor and establish its type.

In our series, we didn't classified the DS meningiomas, the most common symptom was:

- Headaches in 2 patients
- Decreased visual field in 3 patients. One patient with bilateral preblidness.
- Bitemporal hemianopsia in one patient.
- Galactorrhea in one patient.

Even though TS and DS meningiomas have different sites of origin that can be distinguished anatomically, they are often grouped together as TS meningiomas [97; 98; 101]. The differentiation between these two types is confounded by the similarity in clinical presentation and anatomical adjacency [102; 99].

2. Laterosellar meningiomas:

2.1.Cavernous sinus :

Cavernous sinus meningiomas have an estimated incidence of only 0.5 per 100,000. [103] Meningiomas may involve the cavernous sinus either primarily or secondarily. Those originating from within the cavernous sinus may extend to the Meckel cave, medially to the sella, and to the anterior, middle, or infratemporal fossae. Clinoidal, medial sphenoid wing, and petroclival meningiomas may extend to the cavernous sinus secondarily; the cavernous

sinus contains the cavernous segment of the ICA and its branches, the sympathetic plexus and cranial nerves III, IV, and VI, and the first and second divisions of cranial nerve V (V1 and V2).

Clinical features:

Meningiomas originating from the cavernous sinus tend to cause symptoms by compressing or invading nearby neurovascular structures. Given their close proximity to cranial nerves II–VI and the ICA, CSMs often present with neurological deficit. Clinical manifestations were described by KEAN, it is found to be fairly well stereotyped:

- Progressive unilateral involvement of the 3rd, 4th, 5th or 6th nerves, and sometimes retro-orbital headaches.(in our series, one patient has presented with fronto orbital headaches and the 2 others with frontal headaches)

This very gradual appearance of functional disorders causes patients to consult very late in most cases. This period ranges from 1 month to 10 years according to the series [104; 105]. for our series , the period ranges from 6 months to 1 year.

Patients with CSMs most frequently present with:

- Ocular motor deficits such as diplopia, anisocoria, ophthalmoplegia, and ptosis. This was the common symptom in our series, as well as the:
- Visual field deficits caused by optic pathway compression. Optic canal invasion or optic nerve compression secondary to hyperostosis can lead to ipsilateral loss of visual acuity.in our series, 3 patients had decreased vision, one with monocular preblindness.
- Facial numbness, pain, and dysesthesias can result from compression of 1 or multiple branches of cranial nerve V. this was seen in 2 patients in our series.

Authors	Nb of cases	Cranial nerves deficit %						
		II	III	IV	V	VI	VII	VIII
DUFOUR [106]	31	48	35,4	6,4	16	19,3	7,4	6,4
DUMA [107]	34	18	47	24	44	32	18	12
KNOSP [108]	29	NA	62	14	VI (52%) V2(48%) V3 (24%)	55	NA	NA
O'SULLIVAN [109]	34	50	36	15	15	20	6	6
Our series	4	75	75	50	50	25	0	0

TABLE 48 CRANIAL NERVES DEFICIT % REPORTED IN LITTERATURE

Other manifestations rather than nerve disturbance are:

- Pituitary stalk and gland dysfunction, though uncommon, can result from tumor compression and may require endocrine laboratory workup. No endocrinological manifestations in our series.
- Patients with tumors arising from the sphenoid wing that infiltrate the cavernous sinus may present with
- Seizures or hemiparesis. Finally, headaches are commonly associated with CSMs.

	Dolenc	SEPEHRNIA	KIM	Current
Headache	27 (43%)	35 (50%)	12 (57%)	4(100%)
Decreased vision		28 (39%)	9 (43%)	3(75%)
Amaurosis		11 (15%)		
Double vision	25 (40%)	17 (24%)	8 (38%)	3(75%)
Ophthalmoplegia	3 (5%)		14 (67%)	2(50%)
Exophthalmos	17 (27%)	11 (15%)		2(50%)
Pain	5 (8%)			
Sensory loss			7 (30%)	2(50%)
Hemiparesis		6 (8%)		0
Mental changes		4 (6%)		0
Epilepsy			5 (24%)	0
Other				3(75%)

TABLE 49 SYMPTOMS OF CAVERNOUS SINUS PATHOLOGY IN LITERATURE [110; 111]

2.2. Posterior clinoid proces:

Posterior clinoid process (PCP) meningiomas are extremely rare lesions and comprise about 0.7% of central skull base meningiomas [112] . PCP meningioma was first reported by Horiguchi et al. in 2008 [113]. Since PCP meningiomas are rare, and clinically and radiologically similar to meningiomas arising from the anterior clinoid process (ACP) or suprasellar region, PCP meningiomas may not be correctly diagnosed. Although various terminologies have been used to describe this lesion, Sodhi et al. clarified the terminology and separated PCP meningiomas (eccentrically placed or centered on PCP) from other types, such as dorsum sellae and upper clival meningiomas and retrosellar or laterosellar meningiomas

[114; 115; 112]. For our series only one patient had a posterior clinoid process meningiomas. Lesions in this region are primarily of two anatomic types:

- Centrally placed meningiomas located between the two PCPs and arising from the dorsum sellae or upper clival region – which should be referred to as dorsum sellae or upper clival meningiomas.

- Eccentrically placed meningiomas centered on the PCP are true PCP meningiomas.

The term PCP meningioma should be reserved only for meningiomas that are eccentrically placed and centered over the PCP as in our case. Meningiomas arising from the PCP can compress the pituitary stalk anteriorly, the oculomotor nerve laterally or infero-laterally and encase the C1-C2 segment of ICA or its perforators and branches [112].

Clinical features:

A series of 16 cases with PCP meningiomas have been reported, Since little information is available about its characteristics and the treatment strategies.

- Oculomotor palsy was seen in three of the six cases with description of clinical features [116; 112].
- Decreased visual acuity and homonymous hemianopia was seen in two of six cases, due to compression of the optic tract [114].
- diplopia due to oculomotor palsy and decreased visual acuity are similarly observed in ACP meningiomas.

However, homonymous hemianopia might be a distinctive feature of PCP meningiomas because tumor is located immediately below the optic tract. This clinical feature was found in our patient.

	<u>Age</u>	<u>Gender</u>	<u>Neurological symptoms</u>
Goto and Ohata [112] n = 5	51.6 (45–58)	M 3, F2	<u>NA</u>
Ohba et al [116] n = 1	60	<u>M</u>	CN3 palsy
Shukla et al [112] n = 2	50	<u>F</u>	HA, diplopia (CN3)
	41	<u>F</u>	HA, diplopia(CN3)
Sodhi et al [114] n = 1	48	F	HA, VD, HH
our series	<u>48</u>	<u>M</u>	<u>VD, vomiting, HA, HH</u>

TABLE 50 PCP MENINGIOMAS FEATURES IN LITTERATURE

3. Sphenoid wings :

1.1. Lesser sphenoid wing:

Meningiomas are the most common tumors of the sphenoid wing in the skull base, they are accounting for approximately 20% of supratentorial meningiomas [117]. In our series, they account for 19% of the skull base meningioma, anterior and middle fossa.

The first classification for sphenoid wing meningiomas was proposed by Cushing and Eisenhardt. they distinguished between globular meningiomas of the deep or clinoidal third, those of the middle (“alar”), and those of the outer third of the sphenoid ridge (“pterional meningiomas”) [7; 118].

These tumors are classified according to their presentation as a nodular type or en plaque type of tumor. Meningioma en plaque has distinct characteristics that make it a different pathologic cells fill the haversian canals and may spread into the pterion (orbital walls and zygomatic and temporal fossae), the base of the middle cranial fossa, the malar bone, and the orbital rim. These tumors can produce a hyperostotic reaction, which produces exophthalmos and other types of facial deformity [119]. That’s why we opted for the choice to classify them a part. The nodular or globoid meningiomas are those described in this chapter, they are encapsulated tumors of variable size that displaces or invades intracranial arteries or cranial nerves. Characteristically, this tumor has a dural site of implantation through which it receives its blood supply and they are classified according to their site of implantation along the sphenoid wing as inner third, middle third , outer third or external sphenoid wing meningiomas. Some authors subdivide the inner third meningiomas into sphenocavernous tumors (those implanted in the external wall of the cavernous sinus) and clinoidal tumors (implanted on the corresponding clinoid process and projecting toward the anterior cranial fossa). In the classical neurosurgical literature anterior clinoidal meningiomas have not been separated from medial sphenoid wing or inner sphenoid wing meningiomas. Some, however, may grow into the region of the medial sphenoid wing. When clinoidal meningiomas grow to a very large size they can involve the parasellar region in its anteroposterior and mediolateral extensions. In this case the tumor may extend laterally into the cavernous sinus or posteriorly into the region of the posterior clinoid and the petroclival region [120].

In this chapter, we discuss the inner third meningiomas as clinoidal meningiomas, and the sphenocarvernous meningiomas as cavernous sinus meningiomas.

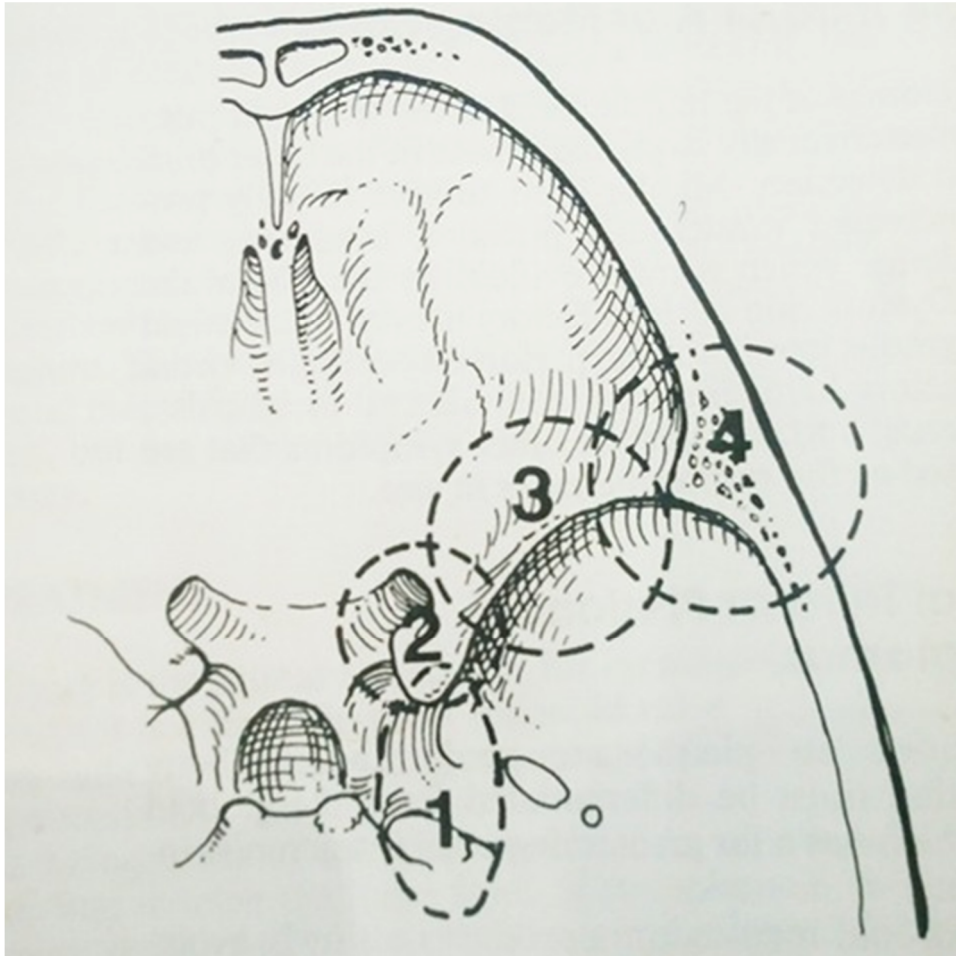


FIGURE 33 SITES OF IMPLANTATION OF NODULAR TYPES OF SPHENOID WING MENINGIOMAS. [120]

1, sphenocavernous; 2, clinoidal ; 3, Alar or middle third; 4, pterional

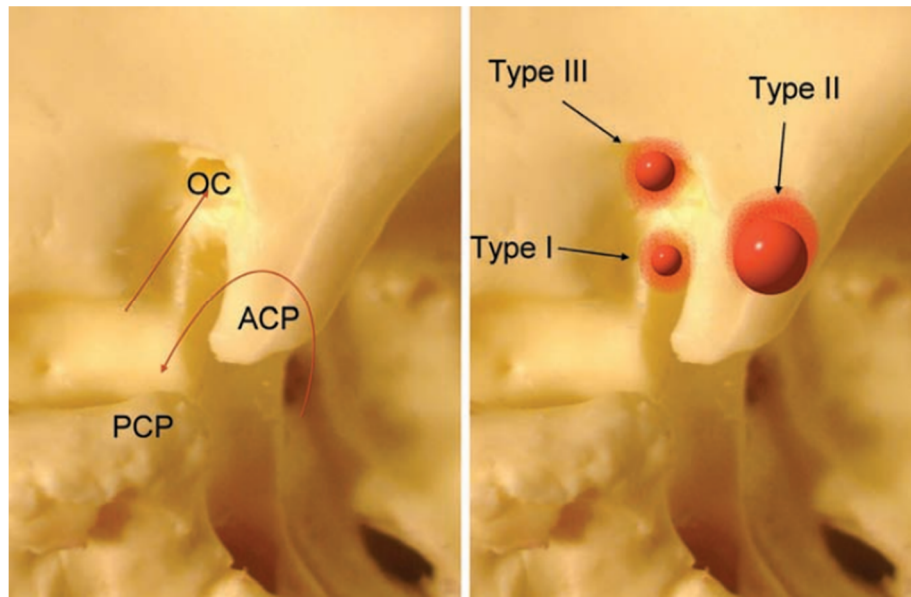


FIGURE 34 BONY ANATOMY OF THE ANTERIOR CLINOID PROCESS REGION AND DISTRIBUTION OF ACPMS [10]

Al-Mefty suggested that clinoidal meningiomas be classified into three different types:

- **Type I** clinoidal meningiomas are thought to arise from the subclinoid dura at the most proximal point of intradural entry of the internal carotid artery, just before the carotid enters into the arachnoid cisternal space. As a result, Al-Mefty suggested that these tumors are extraarachnoid and because of this tend to become more adherent to the internal carotid artery and much more difficult to remove surgically. These are the tumors that have a higher rate of subtotal resection and recurrence.

- **Type II** clinoidal meningiomas are thought to originate from the superolateral aspect of the anterior clinoid process. When these tumors grow, they are invested by the arachnoid layers around the carotid cistern. As a result, the tumor is separated from the internal carotid wall by arachnoid layers that prevent the significant adherence of the tumor to the adventitia of the internal carotid artery wall. This makes the tumors easier to dissect off the wall of the internal carotid artery; as a result, a more complete resection is achievable. Al-Mefty also makes the observation that the growth of type I and II clinoidal meningiomas starts at a distance from

the optic nerve; as a result, the arachnoid membranes of the chiasmatic cistern invest the optic nerve and help protect it from immediate invasion by the tumor.

-**Type III** clinoidal meningiomas originate from the region of the optic foramen and extend into the optic canal. Because of the pattern of their growth within the region of the optic canal, these tumors become symptomatic at an early stage and are diagnosed earlier before they achieve a large size, unlike types I and II [10].

Clinical features: [121]

1.1.1. Anterior Clinoid process meningiomas:

The most common clinical presentation of clinoidal meningiomas consists of:

- Visual disturbances and headaches [120; 122]. They produce a progressive decrease in visual acuity and changes in the visual fields beginning with ipsilateral nasal hemianopsia. As the tumor grows, a superior temporal field defects occur, and eventually the eye become blind [119] .

In our series, 12 from 15 patients had a decreased visual field, 3 patients with monocular blindness and preblindness at the other eye

- Exophthalmos may occur, owing to venous compression within the cavernous sinus; this condition may be more evident with tumor progression toward the orbital apex and in some patients with associated significant hyperostosis of the sphenoid wing. In our series, only one patient had a proptosis. Also this condition is seen more frequently in the sphenocavernous form of the tumor.
- Primary optic atrophy may be evident on the side of the tumor and in tumors producing increased intracranial pressure, and the contralateral optic disc may be swollen and edematous (Foster-Kennedy syndrome).
- Dysfunction of the olfactory nerve in one patient in our series.

Other clinical symptoms usually correlate with the size of the tumor and its extension. For the Tumors that achieve a large size with more lateral extension result in symptoms due to

compression of the parasellar structures. Extension of the tumor into the cavernous sinus region may result in associated:

- Cranial neuropathies [123; 124]. In our series, 2 patients had 4th nerve involvement, and one patient has 5th nerve deficit.

Occasionally some of the tumors extend to the middle temporal fossa and may enlarge posteriorly to compress the temporal lobe, resulting in:

- seizures as it was found in one patient in our study.

Or they may even compress the brain, resulting in:

- Hemiparesis which was found in 5 patients in our series.

In our series, others manifestations occurred including:

- Behavioral and memory disorder in 4 patients.

1.1.2. **Middle third or alar meningiomas:** [119]

- Meningiomas of the middle third of the sphenoid ridge are characteristically larger than those in the clinoidal meningiomas. This was not the case in our series.

localization	Median size cm
Inner third meningiomas	4.23
Middle third meningiomas	4.21

TABLE 51 MEDIAN SIZE OF INNER AND MIDDLE THIRD MENINGIOMAS

Middle third wing meningiomas initially produce:

- Increased intracranial pressure. In our series 100% (n=2).
- Headache 100% (n=2).
- Papilledema, which is more evident on the side of the lesion. In our series, we have found papillary hyperemia and papillary palor.
- Dysfunction of the olfactory nerve, contralateral homonymous hemianopsia, personality changes, visual and olfactory hallucinations, contralateral facial palsy, hemiparesis, and seizures are other symptoms that are manifested as the tumor increases in size. None of the two patients had experienced these symptoms.

1.1.3. External third or pterional meningiomas: [119]

Early and frequent symptoms of globoid pterional meningioma include:

- Hemicranial headaches, in our series n=2 (100%).
- Increased intracranial pressure, in our series 100% (n=2).
- Seizures and Contralateral hemiparesis, which weren't found in our series.

This tumor behaves as either a temporal or frontal mass. Signs of orbital involvement such as a proptosis are not constant.

Clinical features	Previous Series			Our series		
	Medial (%)	Middle (%)	Lateral (%)	Medial (%)	Middle (%)	Lateral (%)
visual disturbance	16 (70)	5 (28)	1 (7)	12(80)	2(100)	2(100)
headaches	6 (26)	5 (28)	7 (47)	14(93)	2(100)	2(100)
vertigo	2 (9)	1 (6)	3 (20)	1 (7)	0	1(50%)
seizures	2 (9)	5 (28)	3 (20)	1 (7)	0	0
memory difficulties/loss	1 (4)	1 (6)	2 (13)	4 (26)	9	1(50)
behavioral change	1 (4)	3 (17)	1 (7)	4(33)	0	0
syncope	1 (4)	2 (11)	0 (0)	0	0	0
language disturbance	0 (0)	1 (6)	4 (27)	1(7)	1(50)	1(50)
amenorrhea	1 (4)	0 (0)	0 (0)			
ptosis	1 (4)	0 (0)	0 (0)	1(7)	0	0
Facial numbness	1 (4)	1 (6)	0 (0)	1(7)	0	0

TABLE 52 SYMPTOMS OF THE SWMS IN A SERIES OF 56 PATIENTS AT DEPARTMENT OF NEUROLOGICAL SURGERY, CALIFORNIA [125].

1.2.Greater sphenoid wing [126]:

They are discovered by the onset of raised intracranial pressure, which is often associated with:

- Seizures, most often generalized. In our series 20% (n=2).

In GRAZIANI study [126] of 11 cases of meningioma of the temporal basal fossa, there were 6 cases of headache and 2 cases of seizures. in our series, from 100 patients, 10 patients have presented with a greater sphenoid wing meningiomas 10%, among which 8 had a tumor size superior to 3cm. 1 patients had a GCS<15 at the admission and died after surgery, these are the common symptoms:

- Headaches. 70% (n= 7)
- Decreased visual acuity due to raised intracranial pressure 80% n= (8)
- Proptosis 2% n=(2)
- Diplopia 1% n=(1)
- Frontal syndrome 1% (n=1) and language impairment 3% (n=3).
- Cranial nerve involvement in larger lesions, in our study, the cranial nerve deficits were 2 patients with 3rd nerve, 1 patient with 5th nerve, 1 patient with 4th nerve.

4. sphenoorbital (En plaque):

Cushing and Eisenhardt first described meningioma en plaque as “the flat spreading tumors (meningiomas en plaque) which provoke hyperostosis of the greater wing of the sphenoid.” Cushing described that the infiltration of the bone by meningioma cells stimulates osteoblastic activity resulting in hyperostosis. This hyperostosis is typical of the sphenoid bone, and is less frequent at other cranial sites. These tumors have been referred to in the literature as sphenoid wing meningioma *en plaque*, pterional meningioma en plaque, hyperostosing meningioma of the sphenoid ridge, invading meningioma of the sphenoid ridge, or more generically as sphenoorbital meningiomas (SOMs) [127].SOMs constitute up to 9% of all intracranial meningiomas [7].in our series, they represent 8% of anterior and middle skull base meningioma.

They originate from the dura of the sphenoid wing, and they can extend into the cavernous sinus, superior orbital fissure (SOF), orbital apex, and convexity dura. Soft tissue growth can spread to extracranial compartments, including the orbit, the infratemporal fossa, and the

temporal fossa. Bone involvement may extend to include the anterior clinoid process and lesser sphenoid wing, the orbital roof, the lateral orbital wall, and the middle fossa base. The tumor may also extend to the optic canal and the paranasal sinuses [7].

Most patients with SOM are middle-aged women whose symptoms are primarily attributable to the hyperostosis [128].

Clinical presentation:

The most common symptom is:

- unilateral, nonpulsating, progressive proptosis (80 to 90%).

87.5% in our series presented with exophthalmos . This proptosis can be explained by the hyperostosis of the orbital walls, the presence of an intraorbital tumor, periorbital tumor infiltration, or venous stasis secondary to ophthalmic vein compression when the tumor enters the cavernous sinus [119].

Other symptoms could be found as:

- optic neuropathy, evidenced by decreased visual acuity which was found in all our patients with SOMs ,

The visual function recorded preoperatively is believed to be directly related to the degree of bone hyperostosis because no meningioma was found directly against the optic nerve or in the optic canal. The exuberant hyperostosis seen in SOM has been demonstrated by Al-Mefty and colleagues [129] to be direct tumor invasion of the bone.

Other cranial nerve (CN) deficits (CN III, IV, V, VI) are seen in 20 to 25% of patients. Even though the oculomotor nerve is the most commonly affected CN besides the optic nerve [130; 131; 132; 133; 134; 135], diplopia is usually on the basis of extraocular muscle restriction due to intraorbital tumor rather than secondary to neuropathy of the ocular motor nerves.

- Skull deformities may be caused by temporal bone hyperostosis, and in some cases, the temporal muscle is infiltrated by the tumor [119].

Conclusion:

The most common revealing symptoms of anterior and middle skull base meningiomas are:

Visual disturbances

Headaches

Others include:

A change in personality, judgment, or motivation, memory deficit noticed by family,

Foster-Kennedy syndrome

Anosmia or hyposmia

Endocrinopathies

Cranial nerve deficit

Seizures, aphasia

Proptosis

Motor deficit

IV- Neuroradiological evaluation:

A. CT scan

Meningiomas typically appear as rounded or elongated extraaxial masses with a broad-based dural attachment. Their extraaxial nature is suggested by the white matter buckling, an inward bowing of a gray-white junction that otherwise appears normal, the presence of a cerebrospinal fluid attenuation cleft, and intense enhancement [136].

1. Density:

Careful attention to the intrinsic appearance of these masses typically reveals that on non-contrast computer tomography (NCCT), 60% to 80% of meningiomas are mildly hyperdense, in the range of 20 to 40 Hounsfield units (HU), while normal unenhanced gray matter measures approximately 16 to 20 HU [137]. This hyperdensity is seen in all histologic types of meningioma [88]. Even higher attenuation values (60 to 100 HU) have been found, primarily in the transitional and fibroblastic types of meningioma, although densities this high were never seen in the angioblastic type [138]. The hyperdensity is due primarily to the presence of calcified psammoma bodies dispersed throughout the tumor. In addition, the fibroblastic and transitional types have a compact cellularity, adding to the overall hyperdensity of these tumors. In our series, 56 patients had a transitional, psomatous, fibroblastic types of meningiomas, 43 of 56 cases had a hyperdense lesion (77%), which concurs with literature findings.

After the administration of intravenous contrast material, more than 80% of meningiomas show a moderate degree of homogenous enhancement and usually increase in density 10 to 40 HU from the NCCT [138].

The study of density in our series shows that in 74 cases, the tumor was hyperdense to the cerebral parenchyma, isodense in 22 cases, and hypodense in 9 cases which goes along with literature findings [139; 137; 138; 140].

2. Calcification

They are defined as a spontaneous density without injection of contrast product in any portion of the tumor. It can take different aspects:

- Focal punctate calcifications which are seen in 15% to 20% of cases [139; 137; 141; 142; 143].
- Most often, mass calcifications of the whole tumor, very dense, sometimes ossified, which are often referred to as "psammomes".

These calcifications usually have attenuation values greater than 250 HU [139] and are obvious on the NCCT. These calcium deposits are of the dystrophic type, occurring in areas of necrosis or previous hemorrhage. Rarely, frank association occurs within a meningioma [144], appearing as a nonspecific calcification on the CT scan. Although meningiomas calcifications, are nonspecific and are actually more common in glial tumor.

Lesions that are diffusely calcified on the NCCT (With overall attenuation values greater than 250 HU) typically show little or no change after contrast administration. This finding of a heavily calcified meningioma with no discernible contrast enhancement is usually associated with a slow-growing lesion [142].

3. Bone abnormalities

Other finding typically revealed in CT scan is bone abnormalities, both hyperostosis and bone destruction seems to be better detected in CT [139; 145; 143] especially in skull base lesions.

4. Perilesional edema:

Despite their extra-axial location, slow growth, and mostly benign character, meningiomas of the skull base are frequently associated with peritumoral edema (More than 60% of cases) [139; 141; 146].

In addition to age and gender, radiological findings, including tumor size, vascularity, tumor location, tumor shape, and histological findings (such as macrophage infiltration), and an increase in the number of dividing cells have been reported as possible causes of PTBE [147];

148; 149; 150]. However, the causes of meningioma with accompanying PTBE have not been identified [151; 152; 153].

The arachnoid plane around the tumor margin is also a factor representing a physiological barrier of the adjacent normal brain tissues from tumors such as meningioma. Previous studies have reported a higher frequency of PTBE in the absence of the arachnoid plane. The arachnoid plane is a brain-cerebrospinal barrier that is not water-permeable. The pia mater is permeable for water and electrolytes but is not permeable for polymers, such as plasma proteins, and the cerebral cortex is not water-permeable. Therefore, vascular edema may occur from plasma proteins and blood plasma flowing into the white matter because of increased vascular permeability. This may occur by edema fluid produced by meningioma and substances that contribute to the development of edema [154].

Some authors have presented evidence of secretion of protein-like substances by meningiomas (VEGF) [155; 156]. Because the arachnoid cap cells (the presumed cells of origin of meningiomas) are derived from epithelial elements, these tissues having secretory properties have an embryologic basis. The secretory properties of meningiomas may also explain the occasional occurrence of a disproportionately large amount of edema associated with small meningiomas [138; 153]. In a study of several small meningiomas associated with a large amount of edema, however, one author found small areas of hypervascularity within a meningothelial tumor with an otherwise unremarkable appearance [157]. This hypervascularity is postulated to add to the edema production by tumor; the lack of a blood-tumor barrier in the capillaries within the meningioma may result in seepage of fluid into the tumor, and this fluid may simply traverse the white matter to drain into the ventricular system [152; 146].

A high SI in T2WI of the tumor indicates a high water content and a high level of vascularity in the tumor [148; 158]. Tumors with high water content can easily spread to adjacent organs because of differences in osmotic pressure [158]. The difference in water content level in tumors appears to be the cause of this result.

Multiple studies describe little or no edema associated with meningiomas of the posterior fossa, whereas those lesions in the frontal or sphenoid wing regions are often associated with a large amount of edema [139; 146; 153; 159]. The significance of this difference is unknown,

although the spread of the edema may have to do with the architecture of the white matter tracts in different areas of the brain [160] .

Atypical and anaplastic meningiomas (GII/GIII) have been reported to show higher cell proliferation rates than benign meningiomas (GI) [161]. Also, PTBE in intracranial meningiomas has been reported to be associated with histological grade [162]. However, the edema itself is nonspecific, as similar amounts of edema may be seen in all histologic type of meningiomas [151; 152; 153; 159].

Several studies have found that the MIB-1 monoclonal antibody, which stains the Ki-67 antigen, acts as an index of growth and meningioma recurrence [162; 163]. Meningiomas, with a high Ki-67 antigen LI, display high levels of vascularity and water permeability [164]. A study on Ki-67 antigen LI and recurrence of partially removed meningioma has found that the higher the Ki-67 antigen LI, the faster the tumor's doubling time and growth rate [162].

In Kim B et al study [165], based on an average Ki-67 antigen LI of 4% from 86 cases, it was concluded that a higher Ki-67 antigen LI leads to a higher frequency of PTBE, consistent with previous findings. PTBE must be considered when deciding on a strategy for the management of a meningioma, because it may be related to perioperative morbidity, invasion potential, and meningioma recurrence.

5. Mass effect:

Most of the tumors produce a mass effect, leading to a deviation of the central structures or an obliteration of the median cavities. This mass effect depends on the size of the tumor as well as the perilesional edema, but this is not specific; since the mass effect is encountered with any type of localized edema.

6. Central necrosis:

It is presented as a focal zone of low attenuation, irregular, poorly limited. It is rarely found in meningiomas according to some authors [166].

It should be noted that in the supra-sellar region, the pituitary adenoma, craniopharyngioma and high density tumors of the pituitary gland may have CT signs similar

to meningiomas [166]. Each of these differential diagnosis and others will be addressed with details in chapter

Some authors have tried to assert the diagnosis of meningioma by defining images that would evince an evolutionary or histological aggressiveness. In fact, the malignant meningiomas cannot be clearly distinguished on the CT data alone, the aggressiveness of the tumor is ultimately better evaluated by examination and post-operative histology (LEFRANCO) [166].

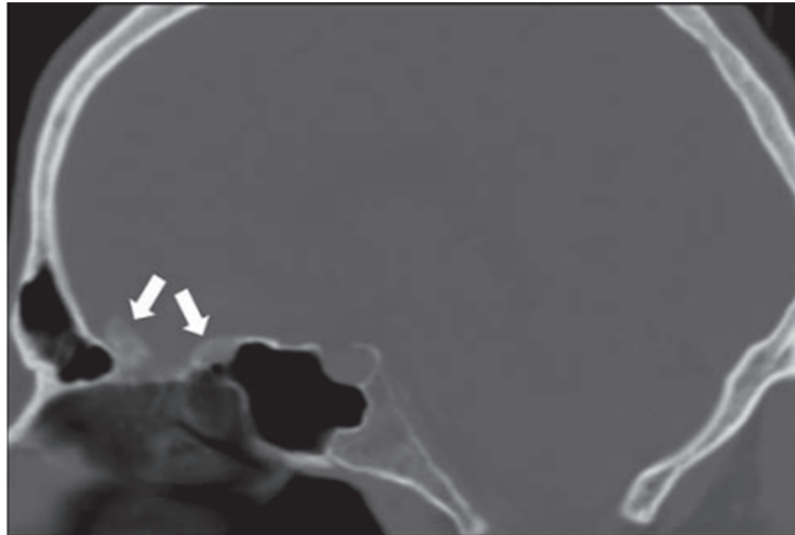


FIGURE 35 SAGITTAL CT AT BONE WINDOW SETTINGS IDENTIFIES HYPEROSTOSIS OF THE ANTERIOR SKULL BASE (ARROWS). [10]

Conclusion: typical features of meningioma in CT scan

Extra-axial lesion
Broad-based dural attachment
Smooth, well defined borders
Hyperdensity to brain on NCCT
White matter buckling
Focal calcium deposits
Moderate homogenous contrast enhancement
Hyperostosis of adjacent bone
Adjacent hypodensity (edema, trapped cerebrospinal fluid)

B. MRI:

Unlike most intracranial tumors, meningioma can theatrically escape MRI diagnosis because they often have signals that in T1 and T2 are similar to those of the normal brain: the difference in intensity between tumor itself and the parenchyma can be very low, leading to false negatives or interpretation errors, in the absence of mass effect. However, current testing protocols including frequent use of Gadolinium authorized in 1986. Make very unlikely false negatives.

The general morphologic characteristics of meningiomas observed in MRI are the same as those observed with CT. the extra-axial location, broad-based dural attachment, and associated mass effect on the subjacent cortex have been described. White matter buckling as a sign of an extra-axial mass is especially well visualized with MRI, owing to the excellent delineation of the gray-white matter interface on most imaging sequences [167]. An aid to the appreciation of the extra-axial location of the mass is the presence of a clear margin separating the meningioma from the adjacent brain. This margin results , in part, from a thin linear signal void due to dura interposed between the tumor and the brain.

There are several studies discussing the signal characteristics of meningiomas at the MRI. The signal intensity of the tumor mass may be rather variable on both t1-, t2-weighted and FLAIR images [168; 169; 170]. on t1-weighted images, most tumors are isointense to the cortical grey matter (from 56% to 94%). This finding contrast with those of most other tumors, which are often markedly hypointense [171; 172; 173]. They also can be mildly hypointense in 20% to 48%, however, hyperintense tumors on t1-weighted images are rare. On t2-weighted images, about 50% of the tumors remain isointense with the brain cortex. Hypointense tumors are less common, from 4% to 18%, whereas hyperintense lesions account for 35% to 44% [168; 169].

In the present study, on t1-weighted images, 35% (n=27) Of the tumors showed low signal, 60% (n=46) Intermediate signal, and 5%(n=4) had high signal. On the t2-weighted images, most tumors 78% (n=57) were hyperintense 17% (n=13) isointense and 9% (n=4) were hypointense to the cortical grey matter. Which is habitual in meningioma [174] .

Meningiomas characteristically show intense enhancement after contrast administration both on CT scan and MRI [168; 169; 175]. This enhancement may be either central or ring-like, and it is explained to the fact that meningiomas capillaries have no blood brain barrier. The tumor enhancement in patients with meningiomas may help to identify anatomic boundaries of larger lesions that may be isointense to the brain on t1-weighted images [168]. In our study, all the meningiomas showed enhancement after contrast administration, which was accentuated in 83% of the cases, and heterogeneous in 64% of the patients.

Cystic foci, hemorrhage and calcifications may be seen in approximately 20% of the patients with meningiomas¹. cystic meningioma could be either isointense or hyperintense at T2, without any correlation with cystic liquid nature (hemosiderinic, necrosis or cerebrospinal) [176]. Wasensko distinguished the intratumor cysts and adjacent intracerebral cysts interposed between the tumor and cerebral parenchyma. Enhancement of cyst wall following gadolinium is in favor of meningiomatous nature. Punctate calcifications, if they are large enough, appear as foci of signal void. As is well known, small punctate calcifications are not reliably identified on MRI [168], and if identification of these calcifications is important, a CT examination should be performed.

The presence of brain edema is frequently reported in patients with meningiomas [177; 158; 178]. Several studies tried to elucidate the tumor characteristics associated with the presence of edema. The tumor size, location, signals intensity on t2-weighted images and invasive pattern of brain-tumor interface were related to the presence of edema in patients with meningiomas. However, the histological subtypes were not related to this finding [177; 158]. Therefore, of those meningiomas that are isointense with brain, only the syncytial tumors have been found to show a significant amount of vasogenic edema [179]. In the present study, 78% of the patients showed brain edema, which more commonly was discrete. Hyperdensity on T2-weighted images indicates soft tumor consistency and microhypervascularity, which was described by Zimmerman and coll [167]. Nakau et al. [180] studied the correlation of the MRI and histopathological findings in nine cases of meningiomas with dural tail sign. They suggested that tumor cell nests in the dura mater of those patients, making the surgical resection of these areas mandatory. Almost 35% of the patients with meningiomas may present the dural tail signal on post-contrast t1-weighted images [178], it was described for the convexity and portocerebral angle meningioma, and not for suprasellar meningioma.

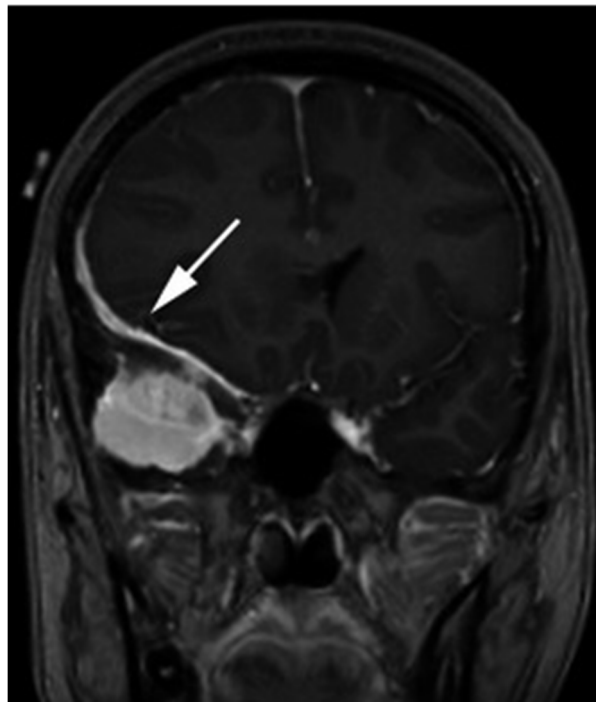


FIGURE 36 DURAL TAIL IN MENINGIOMA (ARROW) [181]

The present study has several limitations. First, this retrospective study was based on the analysis of images recorded; As a result, in several cases, only a few images of each sequence were recorded and analyzed.

Finally, Ct scan remains favorable to the MRI concerning the visualization of calcifications, hyperostosis. However, displacements of neighboring structures, accurate with precision the site of meningioma, the presence of a fluid interface tumor-cerebral parenchyma, perilesional edema are better analyzed at the MRI.

Small meningiomas are often difficult to visualize on CT scans because of the density of the nearby change. On contrast-enhanced MRI, these lesions become starkly outlined between the hypointense inner table of skull and the enhanced brain parenchyma. This finding is of particular value in the evaluation of meningiomas at the skull base, which are difficult to visualize on CT scan. It remains to mention that the MRI is more efficient in the differential diagnosis as well as in the tumor extension.

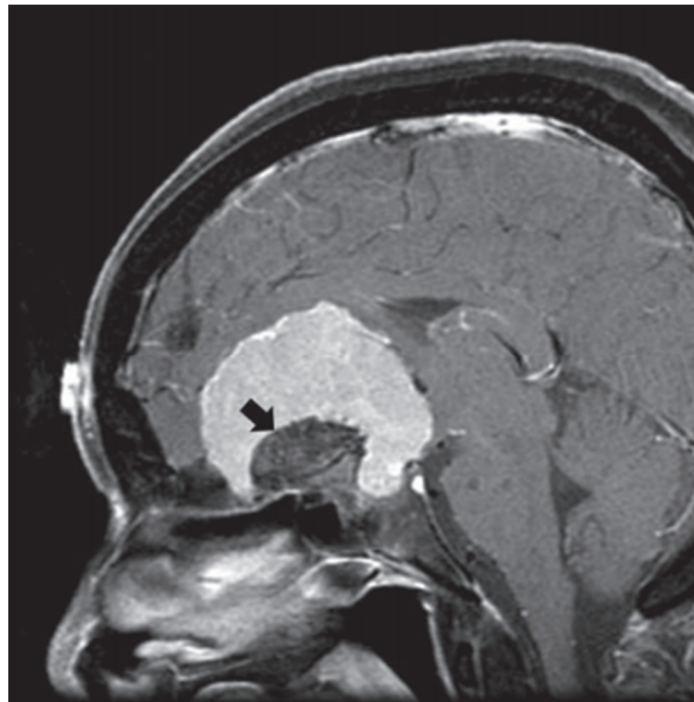


FIGURE 37 SAGITTAL POST CONTRAST T1-WEIGHTED MRI REVEALS A LARGE TUMOR EXTENDING BACK INTO THE SELLA TURCICA. [10]

After having discussed the most important neuroradiological assessment, we can say that the analysis of all the clinical manifestation, the plain X rays, the CT scan and the MRI makes it possible in 100% of the cases to make the diagnosis of meningioma. Now, Remains to define the place of angiography.

Conclusion: Typical features of meningiomas in the MRI

Broad-based dural attachment
Thin line of signal void separating mass from cortex
Surrounding edema well visualized
Signal changes in skull due to tumor infiltration
T1 weighted images isointense slightly hypointense to gray matter
T2-weighted images isointense or mildly hyperintense to gray matter
Moderately intense homogenous contrast enhancement

After discussing the most important neuroradiological assessment, it can be said that the analysis of all the clinical manifestation, the plain X rays, the CT scan and the MRI makes it possible in 100% of the cases to make the diagnosis of meningioma. Now, the next step is to define the place of angiography.

C. Angiography [166]:

Extra-axial masses, including meningiomas, cause characteristic displacement of the cerebral vasculature depending on the size and location of the mass. In general, the classic finding is displacement of the cortical and veins away from the inner table [182]. One may need to obtain oblique views to appreciate the extent of this vessel displacement. Occasionally, there appears a 'bowl' of cerebral vessels consisting of multiple displaced cerebral vessels surrounding the subjacent meningioma [183].

Overall, approximately 50% to 60% of meningiomas show arteriographic features of enlarged feeder branches, neovascularity within the tumor, or a parenchymal 'stain' seen in

the later phases of the arteriogram [183; 184]. Classically, radial orientation of the many small vessels within the tumor itself is found and is referred to as a ‘sunburst’ or ‘spokewheel’ appearance, however, this pattern is very rare in skull base lesions [185; 186; 184].

Another appearance of arteriography which strongly suggests a meningioma is an enlarged, tortuous, nontapering middle meningeal artery branches, even in the absence of demonstrable neovascularity [187].

Finally, an additional factor of extreme surgical importance is the identification of arterial encasement by a meningioma. This condition occurs most often with those meningiomas in the parasellar and suprasellar locations, as well as with those around the clivus and foramen magnum. Arteriography may disclose arterial displacement by the mass, but it doesn’t necessarily identify neoplastic tissue encircling the vessel. The arteriographic criteria for the diagnosis of arterial encasement are narrowing and irregularity of the lumen of the involved artery. Many cases occur, however, in which the artery is encased without visible changes in lumen. Because of the multiplanar imaging capacity as well as its capability to identify a vessel within a tumor mass, MRI is superior to arteriography for the identification of arterial encasement of a vessel by a meningioma [187].

Inward displacement of cortical vessels (i.e., extra axial mass effect)
 Radial configuration of tumor vessels (spokewheel, sunburst) , persistent dense
 homogenous stain (very rare in skull base meningiomas)
 Absence of early venous filling
 Arterial encasement

V- Differential diagnosis: [187]

A. Hyperostosis :

1. Osteoma:

It is a neoplasm that most commonly involves the skull, although other bones may also be affected. These lesions are benign and have the histological appearance of normal bone. Intracranial osteomas are detected as small, incidental radiographic findings, although these

neoplasms may become quite large and cause mass effect on the adjacent brain parenchyma. No signs of increased marking are found, and arteriography reveals no sign of tumor vasculature. Detailed evaluation of the radiographs may demonstrate the smooth inner contour of the lesions, as opposed to often speculated margins seen with meningiomas.

2. Fibrous dysplasia:

This skeletal condition causes bone thickening and hyperdensity as a result of replacement of the medullary cavity of the bone by fibrous tissue. It may involve one or many bones (monostotic or polyostotic forms). When this process involves the skull, it commonly involves other bones as well. Radiographically, the bone in the affected areas is thickened and sclerotic and has lost the trabecular markings that result in the “ground glass” appearance.

With fibrous dysplasia, the inner table is typically smooth, whereas meningiomas often have a roughened, spiculated appearance. The skull base is involved most often although the vault may also be affected. Distinct from most meningiomas, fibrous dysplasia often involves the facial bones. The differentiation of fibrous dysplasia from meningioma is usually not difficult, except with en plaque meningiomas of the sphenoid wing. Arteriography, however typically reveals no significant abnormal vascular supply to the areas of fibrous dysplasia from the meningeal vessels.

3. Paget’s disease:

It causes bone thickening and hyperostosis. Unlike meningiomas, however, Paget’s disease thickens the calvarium by widening the diploic space primarily and the outer table secondarily. And it usually involves the inner table last. Although the skull base is most often involved, the calvarium is often affected. Pagetoid involvement of the skull base may result in basilar invagination because of softening of the bone, which is a rare finding in skull base meningiomas. A differential feature of paget’s disease is lack of associated intracranial calcifications.

B. Bone destruction:

When bone destruction that is secondary to meningioma occurs, it is almost always associated with adjacent areas of hyperostosis. A purely destructive lesion is much more likely to be caused by a primary sarcoma or a metastasis to the skull. Pneumosinus dilatans, or “blistering” of the skull, is a bone reaction to the local presence of a meningioma: this reaction is specific but difficult to recognize. In such cases, the meningioma is adjacent to the planum sphenoidale or tuberculum sellae. The inner table in the area of the planum sphenoidale becomes elevated, with upward bulging of the posterior ethmoidal air cells and the sphenoidal sinus. This condition is commonly associated with variable hyperostosis of the planum sphenoidale, which may be subtle and difficult to visualize without the assistance of CT.

C. Enlarged vascular markings:

The differential diagnosis of increased vascular markings in the calvarium is relatively small. Vascular malformations may enlarge the grooves. Although arteriography makes the diagnosis readily apparent. Other tumors involving the meningeal vessels are relatively aggressive (e.g., infiltrating gliomas, sarcomas, and metastasis) and the time course of tumor development is usually insufficient to cause widening or tortuosity of the osseous grooves. A meningioma that has undergone malignant transformation may have widened vascular channels, although this finding is usually combined with gross destructive bone changes. Few cases of gliomas have been reported, as have cases of fibrous disease associated with hypervascularity. Paget’s disease of the skull typically causes dilatation of the meningeal vessels. However, the gross hyperostosis of the disease often masks the widened vascular grooves of the skull.

D. Tumoral calcification:

The differential diagnosis for abnormal intracranial calcifications is usually between neoplasia as gliomas may harbor intracranial calcifications, which are especially common in

oligodendrogliomas but are also seen in astrocytomas, ependymomas, choroid plexus tumors, and craniopharyngiomas. and inflammatory conditions.

Chronic subdural hematomas may demonstrate curvilinear calcifications near the calvarium, although meningiomas at the skull base only rarely mimic vascular calcifications. Vascular malformations may also calcify. These calcifications have a variable appearance. They may be curvilinear, conforming to the arterial wall, or they may appear as globular, dystrophic deposits in areas of previous hemorrhage. Phleboliths may also be seen in vascular malformations, although they are uncommon and difficult to see on plain radiographic.

E. By location:

1. Suprasellar:

1.1. Pituitary adenoma [188]:

These tumors are the most frequent of suprasellar tumors. The differential diagnosis arises only in cases of non-secretory adenoma. it is very important to differentiate the intra- and suprasellar meningioma from the pituitary adenoma, because the approach varies depending on the tumor, craniotomy for meningioma, whereas an endoscopic transsphenoidal surgery, is preferred for most pituitary adenomas. Bone reaction revealed in plain X-ray due to pituitary macroadenoma and meningioma is similar. These tumors can cause the enlargement of the sella turcica and destruction of the floor of the sellae. Even, enhancement characteristics of a pituitary adenoma and a meningioma on CT and MRI may be similar. However, MRI with contrast can aid us in differentiating a sellae meningioma from a pituitary adenoma. There is heterogeneous, relatively poor enhancement in pituitary adenomas; whereas there is bright, homogeneous enhancement in meningiomas. Also, dural tail and normal sella is a very important MRI finding in a meningioma. Additionally, using angiography can more helpful for distinguish between these tumors.

1.2. Craniopharyngioma :

Craniopharyngiomas occur most commonly in childhood and adolescence and in later adult life after age 50 years; they most frequently arise in the pituitary stalk and tends to extent into the hypothalamus. The morphological heterogeneity of these tumors accounts for

the different radiological aspects that may be encountered. Calcifications, different varieties of cysts can cohabit within the same tumor.

1.3. Giant aneurysm :

The giant aneurysms can sometimes truly resemble a globular meningioma in supra or laterosellar region. Detailed appreciation of the curvilinear calcifications of blood vessel as well as intraluminal thrombus are often provided by the MRI [174].

1.4. Optochiasmatic glioma :

Gliomas of the optic chiasm and hypothalamus account for 10-15% of supratentorial tumors in children. Males and females are approximately equally affected. 20-50% of patients with hypothalamic gliomas have a positive family history of neurofibromatosis type 1 (NF1). Gliomas of the optic chiasm and hypothalamus in children with NF1 usually have more indolent course. Tumours may grow more slowly and occasionally regress spontaneously. Clinical features may include decreased visual acuity / optic atrophy ≈50%, MR imaging is optimal for showing the relationship of the mass to the hypothalamus, optic chiasm, and infundibulum as well as the intraorbital and intracanalicular components of the mass. Large tumors are typically heterogeneous with cystic and solid components. The signal is almost always hypointense in T1 and hyperintense in T2 [174].

2. Lesser sphenoid wings and laterosellar meningioma:

Metastasis and Fibrous dysplasia

3. En plaque:

Fibrous dysplasia, osteoma, osteoblastoma, Paget disease, hyperostosis frontalis interna, osteoblastic metastases, erythroid hyperplasia, and sarcoid may mimic hyperostosing meningiomas and should be considered in the differential diagnosis [10].

VI- Anterior and middle skull base surgery:

Many physicians regard surgery as the treatment of choice for patients with apparently respectable meningiomas. The likelihood of accomplishing a complete resection is related to the site and extent of the tumor. Skull base meningioma can be particularly challenging because they often cannot be completely resected. The basis treatment surgery was described and presented by Harvey Cushing and Louis Eisenhard [7].

A. Preoperative preparation:

1. Drugs

Anticoagulation

Bases on 2008 guideline recommendations, the warfarin or the acenocoumarol should be stopped 5 days and antiplatelet therapies (aspirin or clopidogrel) 7 to 10 days before a surgical procedure [189]. They also suggest bridging during the perioperative period with low molecular weight heparin or ultrafractionated heparin. These should be stopped 24 hours before the scheduled operation. For high bleeding risk procedures, they recommend restarting bridging therapy 48 to 72 hours postoperatively or when hemostasis has been obtained, or withholding bridging therapy altogether [189]. The use of both pre- and postoperative anticoagulation has not been shown to affect postoperative intracranial hemorrhage in meningioma patients [190; 191]. Patients at very high thromboembolic risk, such as those with mechanical mitral valves or recent thromboembolism, may benefit from bridging with parenteral anticoagulants.

Preoperative Seizure Prophylaxis

Antiepileptic medication should naturally be continued during the perioperative period in patients with a known history of seizures. For meningioma patients with no history of seizures, however, a meta-analysis of five randomized controlled trials in patients with primary brain neoplasms found no effect of prophylactic antiepileptic medication on seizure control [192]. The American Academy of Neurology does not recommend the use of antiepileptic medications in brain tumor patients with no history of seizures [192; 193].

Preoperative Beta-Blockade:

Much controversy exists regarding the benefit of perioperative β -blockade. Large randomized trials have shown that prophylactic use of β -blockers can prevent postoperative cardiac complications in higher-risk patients. However, overly aggressive use of these medications increases the risk of stroke and all-cause mortality [194; 195]. With regard to most neurosurgical operations, guidelines recommend continuing β -blockers in patients already taking them to treat cardiac diseases such as angina, hypertension, or arrhythmia [196]. They may be cautiously started in patients with more than one Revised Cardiac Risk Index predictor.

Other Preoperative Medication Considerations

There are other comorbidities and medications that must be considered before surgical resection of a meningioma. Poorly controlled diabetic patients are at risk of infectious complications and higher mortality rates. In addition, use of oral hypoglycemic can lead to several adverse effects in the perioperative period, including hypoglycemia, and should be stopped preoperatively. Glycemic control should be managed with insulin intraoperatively and during the immediate postoperative period. Patients on chronic steroid therapy should also be assessed and the use of stress-dose steroids considered perioperatively.

2. Preoperative embolization: POE

This is a summary of the advantages and demonstrated risks reported by literature :
[197; 198]

Advantages	Demonstrated risks
Limiting surgical blood loss, shortening operative times, causing tumor softening secondary to postembolization necrosis decreased need to manipulate critical structures due to improved visibility, decreased need for cautery	Thromboembolic events due to catheterization of small vessels or migration of embolic materials into vessels feeding the brain. Cranial nerve deficits from the occlusion of the vaso nervosum by small-sized particle or liquid embolic material. Intratumoral hemorrhage due to tumor necrosis or rupture of fragile tumor vasculature; Postembolization swelling leading to increased mass effect; and general complications related to angiography, eg, groin or retroperitoneal hematomas or femoral artery arteriovenous fistulas.

TABLE 53 ADVANTAGES AND DISADVANTAGES OF PREOPERATIVE EMBOLIZATION

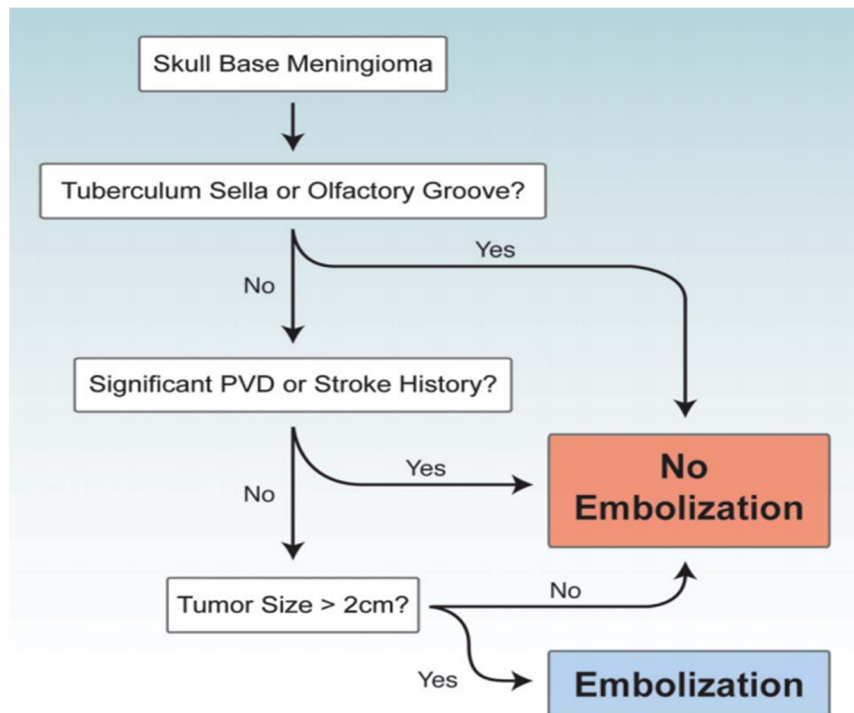


FIGURE 38 SELECTING PATIENTS WITH MENINGIOMA FOR POE [198]

B. Surgical management:

1. Position:

The positioning of the patient is a very important step. It must respond to certain requirements:

- ✓ The head must be above the heart.
- ✓ Avoid excessive flexion, extension and rotation of the head.

This has to be respected because if not, it can lead to intraoperative cerebral turgescence and contribute to develop or to increase vasogenic edema.

2. Preoperative management:

Prophylactic antibiotic therapy is systematically administered prior to incision and should be repeated if the duration of the procedure exceeds four hours.

Good brain relaxation can be achieved by observing normoxia, using moderate hypocapnia between 30 and 35 mmHg, administering furosemide IV 0.25 mg/kg or 0.5 to 1 G/kg of mannitol 20%. Some neurosurgeons place lumbar drainage most often after induction and will only be functional after opening the dura mater in order to avoid any risk of cerebral hernia.

3. Neuronavigation:

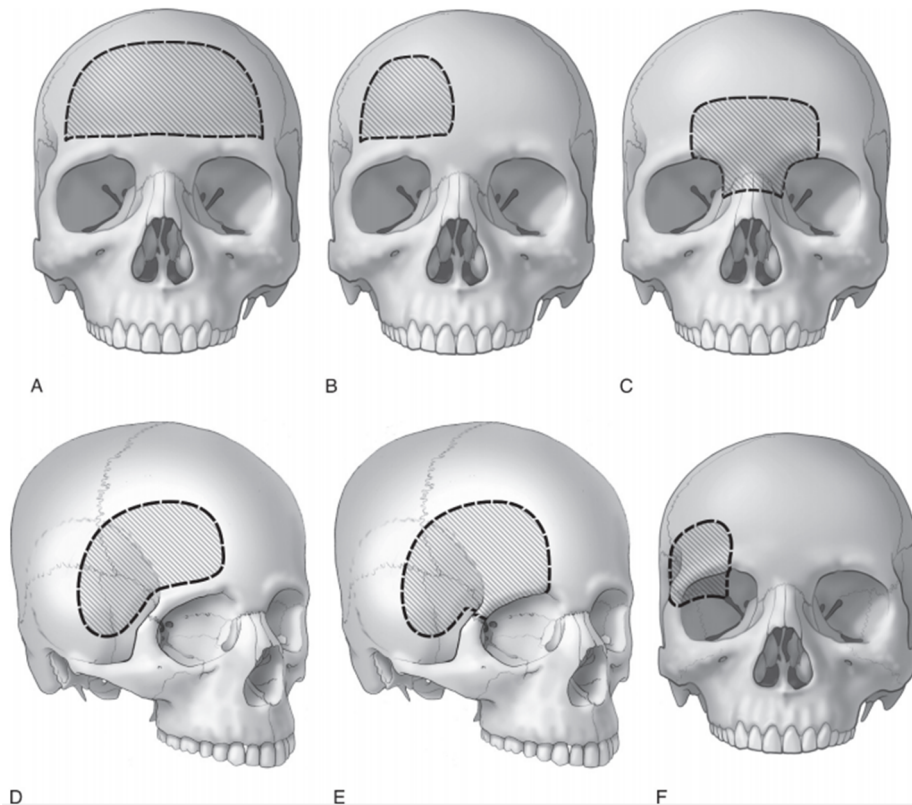
To accomplish transoperative neuronavigation usage, preoperative images need to be acquired using a specific protocol and fiducials. Later, the data are transferred to a Workstation for surgery planning and then, transferred to neuronavigator. Although there are several different systems available, all of them work involving the same steps.

For skull base navigation, CT/MRI fusion should always be considered: there will be a special reliability in neuronavigation, since the surgeon will aim to see bone and fixed structures. In anterior fossa meningiomas surgery, neuronavigation is not necessary for craniotomy, as they usually demand a frontolateral approach. During surgery, neuronavigation can be used before and after dural opening to frontal sinus identification, in order to determine tumor relationship with midline, olfactory groove, optic nerves and internal carotid arteries. The relevant anatomy may be marked in surgical planning. Also, neuronavigation should help to show the position during tumor debulking, especially when approaching posterior structures such as the

infundibulum. Sphenoid wing and cavernous sinus meningiomas Sphenoid wing and cavernous sinus meningiomas can be accessed using a pterional approach and its variants without the need for neuronavigation [199]. However, it can provide valuable intraoperative information during tumor debulking, as the location of vascular structures distorted by the tumor. The mesial structures, including cavernous sinus, can be identified without accuracy loss due to brain-shifting, as these structures remain attached to skull base.

4. Surgical approach and technique:

Since there are no strict recommendations on how to get access to the tumor, knowing the location of adjacent eloquent brain areas, cranial nerves, arteries and veins is essential to determine the most efficient and safe approach. In this chapter, we will describe some efficient approaches for treating skull base meningiomas anterior and middle fossa.



A: bifrontal .B: unifrontal C: bifrontal with the orbital bars. D pterional C an orbital osteotomy

FIGURE 39 ILLUSTRATION SHOWING APPROACHES FOR, ANTERIOR AND MIDDLE SKULL BASE MENINGIOMAS [200].

1.1. Anterior fossa:

1.1.1. Olfactory groove: [201]

Unilateral subfrontal approach :

Francesco Durante performed the first successful resection of OGM in 1885 via a left frontal craniotomy [202]. In 1938, Cushing and Eisenhardt described the surgical principles of the OGM resection in a series of 22 patients through a unilateral subfrontal approach [7]. Although there are many publications concerning the treatment of OGMs in the literature, the optimal surgical approach to these tumors remains controversial. The common approaches include pterional and subfrontal approaches, but endoscopic, lateral-orbital, and interhemispheric approaches have also been described [201] . A comparison of the advantages and disadvantages of the two classical approaches to OGMs is mandatory (**See Table 54**) . But Before adopting any approach, certain steps must be followed: Early interruption of blood supply , Visualization of origin along cranial base , Dissection, tumor debulking and continued devascularization as follow:

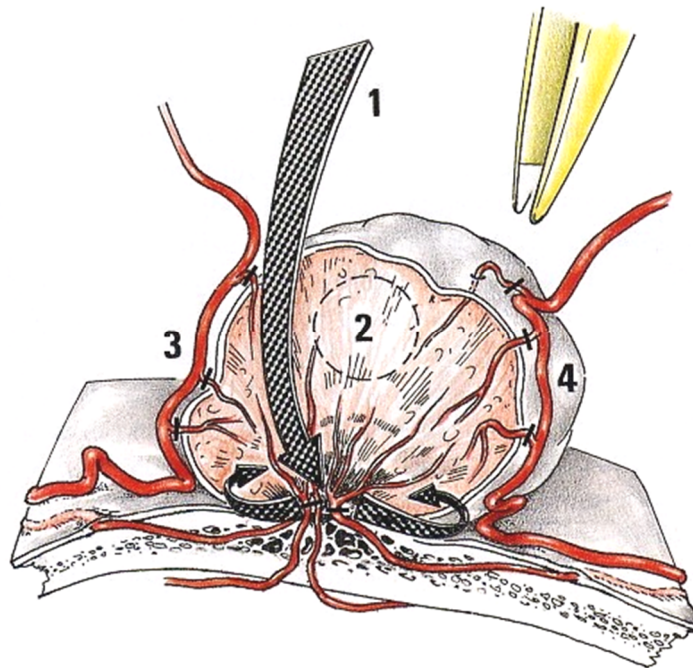


FIGURE 40 DEVASCARLIZATION STEPS OF MENINGIOMA [201]

Devascularization steps:

1. Early interruption of blood supply;

2. Central enucleation;
3. Interruption of tumor blood supply.

Identification and preservation of optic apparatus, olfactory nerve, cerebral vessels ,resection of involved bone and dura in the cranial base, Repair of surgical defects.

For tumors less than 3 cm, unilateral subfrontal approach is more used with orbital osteotomy (Lateral supraorbital); otherwise, Some neurosurgeons use the subfrontal approach for all OGMs.

Bifrontal approach:

The bifrontal approach is performed in larger tumors because of the larger access to the anterior skull base, the opportunity to devascularize the tumor early in the procedure, and the ability to create a robust vascularized reconstruction. Good visualization of the optic apparatus, cerebral vessels, and floor of the anterior cranial fossa is required to permit preservation of critical structures and repair of surgical defects. Access to the anterior skull base is critical in those tumors causing hyperostosis and particularly those invading the ethmoid sinuses; this access may be lacking in the frontolateral-type of approaches [201].

DeMonte and Al-Mefty [203] use a unilateral of bifrontal exposure with resection of the orbital rim on one side. Babu and colleagues [204] prefer a unilateral frontal craniotomy with an interhemispheric approach. For this later, occlusion of the superior sagittal sinus is sometimes necessary. In most cases, this occlusion is without squeals if performed in the frontal third. Sekhar and coll introduced the concept of ethmoidectomy via cranial exposure in case of intra-ethmoidal extension. Currently, the treatment of olfactory meningiomas as suggested by symon is based on an approach that may vary depending on the size and extent of the tumor. Yazargil recommends the pterional approach as a standard approach for OGMs [12]. We advocated the use of pterional approach if the surgeon is comfortable with it, and the tumor size is compatible.

Approach	Advantage	Disadvantage
Pterional	-Optic apparatus and ACA seen early -Early cistern opening -drains cerebrospinal fluid -Avoids frontal sinus entry -Shorter operative time -Shorter distance to ipsilateral tumor	-Narrow working space -Upper portion of tumor may be hidden -Greater distance to contralateral tumor -Orbital roof height obscures base
Subfrontal	-Wide frontal exposure -Direct access to cranial base -Early division of main blood supply -Easier to repair cranial base	-Frontal sinus opened -SSS divided -ACA and optic apparatus seen late

TABLE 54 ADVANTAGES AND DISADVANTAGES OF THE PT AND SF APPROACH [81]

The internal tumor debulking with the ultrasonic aspirator alternates with dissection of the tumor off of the frontal lobes. The olfactory nerves should be identified laterally to the tumor and can anatomically be preserved in a surprising number of cases, if only unilaterally. As the tumor is debulked further, its superior, posterior, and inferior margins can be dissected in sequence with identification of the ACA and optic apparatus. The posterior arachnoidal membranes are intact in nearly all cases of primary operation and permit a relatively straightforward dissection from the optic nerves, pituitary stalk, and blood vessels of the Circle of Willis. Care must be taken not to mistake these vessels for perforating arteries that supply the optic chiasm and hypothalamus. The anterior cerebral vessels can become incorporated into very large tumors, and careful sharp dissection is required to free them from the tumor. If the tumor is adherent to perforating or other vessels that cannot be divided, it is best to leave a small amount of tumor behind rather than risk vascular injury and a possible neurological deficit. After the tumor has been resected, attention should be turned toward the floor of the anterior cranial fossa. Any hyperostotic bone should be removed by drill curettage and the dura of origin removed to reduce the risk of recurrence. Tumor extension into the ethmoid sinuses, nasal cavity, or orbits should be completely resected. The dura is then closed primarily or with the aid of a dural substitute. The large piece of vascularized pericranium that was preserved in the initial portion of the procedure is then brought down over the floor of the

anterior cranial fossa and secured in place using holes drilled in the planum sphenoidale. The orbital osteotomy and frontal bone flap are then plated back into place without compressing the pericranial flap to avoid graft swelling or infarction.

1.1.2. Roof of orbit:

The unilateral frontal approach is privileged for the orbital roof meningiomas, either right or left depending on the site of the meningioma.

1.2. Middle fossa:

1.2.1. Suprasellar meningiomas:

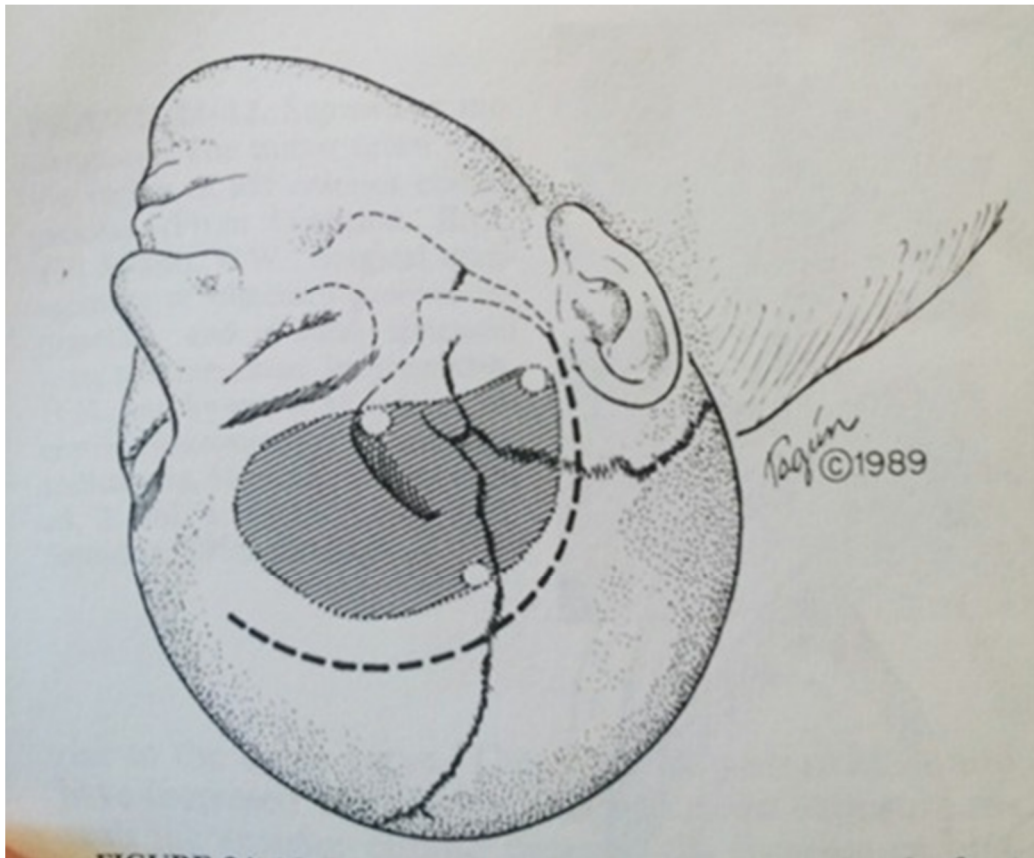
Three different approaches were been described for the suprasellar meningioma, subfrontal, bifrontal and pterional approach.

For most patients, a subfrontal exposure elevating the frontal lobe just in front of the sphenoid wing is preferred [205; 206] ; a left subfrontal exposure is used when the tumor bulk is greater on that side. Occasionally, for large tumors, a bifrontal exposure is indicated. Mac carty [207] and co-workers and Andrews and Wilson have also used the right subfrontal approach unless the visual loss is greater on the left side. Kempe and gristoli and associates [88] have also described this approach. logue and simon use a unilateral right subfrontal exposure but approach the tumor along the midline. In large tumors, macCarty and colleagues and al-Mefty and associates [97] use bifrontal craniotomy.

After making the incision and the burr hole, the lateral portion of the sphenoid wing is removed, as is bone over the anterior superior temporal region. After dural sutures are placed along the edge of the craniotomy opening to control epidural bleeding, the dura is opened over the inferior frontal and anterior temporal regions.

The frontal lobe should be carefully elevated along the sphenoid wing. The posterior part of the olfactory tract is visible and normally leads the surgeon to the optic nerve. Evidence of the tumor may appear in the dura anterior to the optic nerve. The dura may be reddish and have increased vascularity. Slightly more exposure reveals the anterior clinoid process, the internal carotid artery, and a varying portion of the right optic nerve, depending on the size of the tumor (**See fig 41**). In patients with smaller tumors, the arachnoid over the lateral optic nerve and internal carotid artery is opened, and cerebrospinal fluid is aspirated to provide further

decompression. Large tumors may surround both optic nerves, grow beneath the optic nerves to involve the medial wall of the internal carotid artery and its branches, lift the A1 segments of the anterior cerebral arteries off the chiasm, and adhere to the A2 segments of these arteries. The frontal lobe is carefully freed from the surface of the tumor, and self-retaining retractors are applied.



[FIGURE 41 FRONTO TEMPORAL APPROACH \[11\]](#)

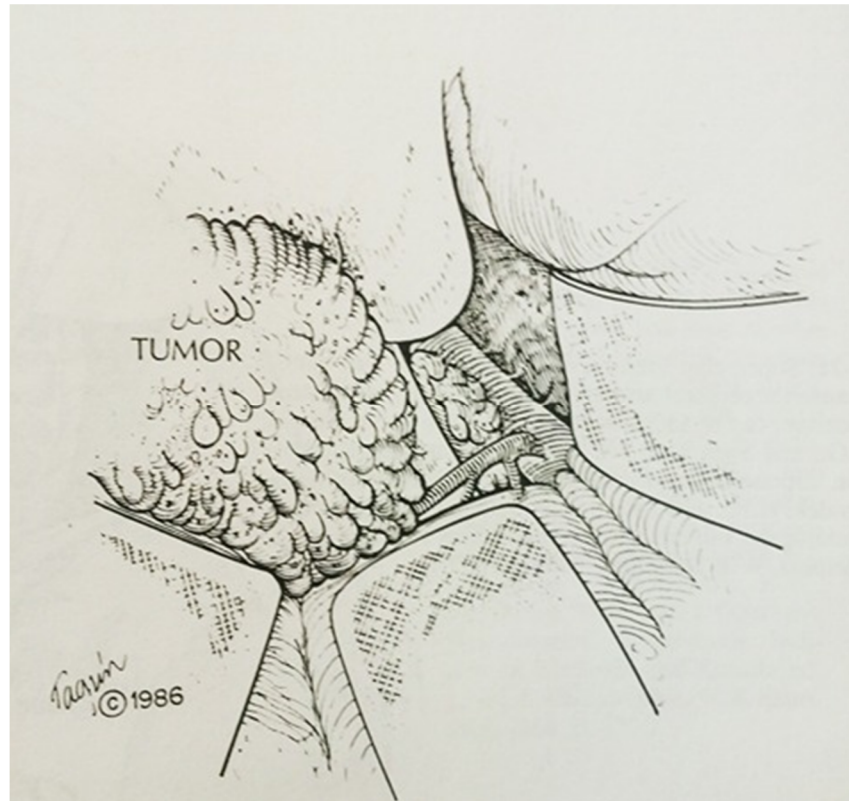


FIGURE 42: SUPRASELLAR MENINGIOMA. [11]

tumor surrounds a portion of the right optic Nerve and right anterior cerebral artery and displaces the right internal carotid artery laterally.

The tumor capsule is opened. The attachments of the tumor along the planum, tuberculum and anterior clinoid process are divided to interrupt the blood supply as it comes into this area.

As the tumor is removed from between the optic nerves and in front of the chiasm, thickened arachnoid may be encountered. Just beneath this arachnoid is the pituitary stalk, which may have been displaced by the tumor. This structure usually can be preserved. After removal of the tumor is completed, the dura over the tuberculum and adjacent area is removed. Usually, this removal is all that is required. In some patients, tumor may grow into the optic foramen or involve the dura under the optic nerve. Removal of bone over the optic canal may be required, but tumor may need to be left in this area.

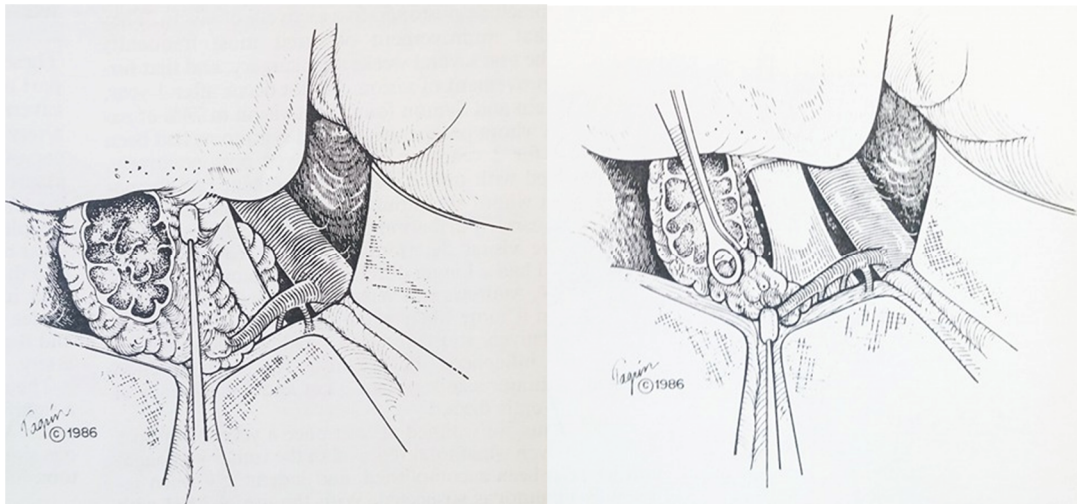


FIGURE 43 SUPRASELLAR MENINGIOMA [11].

internal decompression of the tumor had been accomplished. the attachments of the right optic nerve are being separated.

Some particularities:

Diaphragm sellae:

Surgical approaches include the cranio-orbital approach for Types A and B and the transcranial-transsphenoidal approach for Type C. Surgery is more difficult than for tuberculum sellae meningiomas because of the deep location and the difficulty of dissecting Types A and B from the pituitary stalk. Repair of the sphenoid sinus to prevent cerebrospinal fluid leakage is mandatory for Type C tumors.

Tuberculum sellae:

The main surgical approaches for these tumors as it was mentioned before, are, the pterional , subfrontal approaches, and the superior interhemispheric approach which was described first and which might decrease surgical injury to the olfactory tractus.

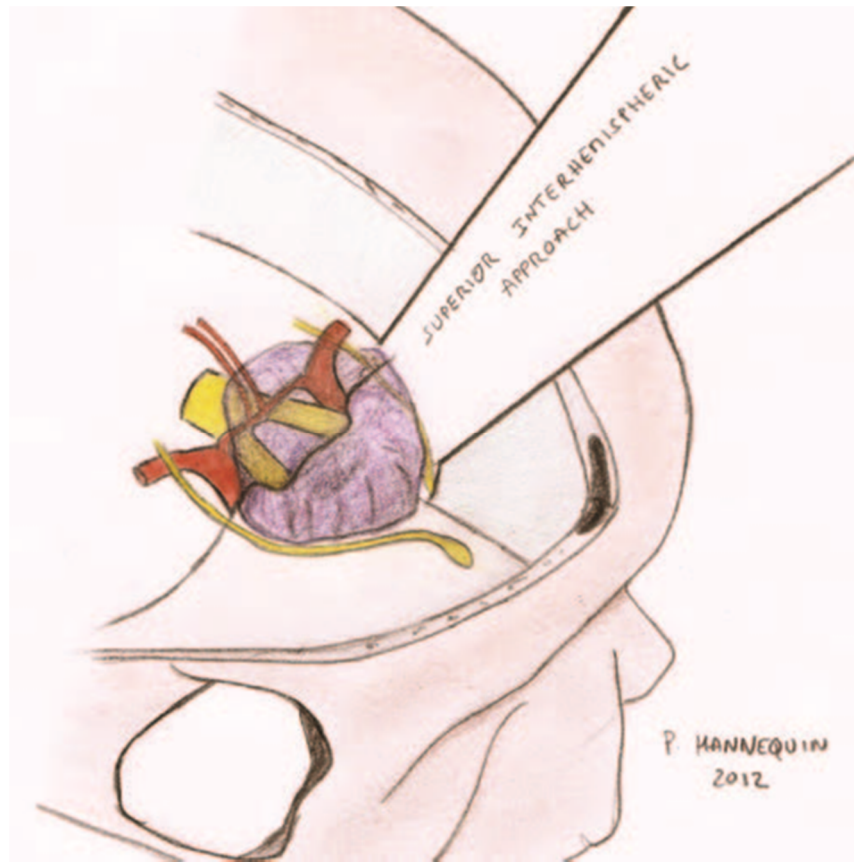


FIGURE 44 ILLUSTRATION SHOWING THE SUPERIOR INTERHEMISPHERIC APPROACH [208].

This three-quarter view shows the interhemispheric approach to a TSM. The TSM, which has a transparent appearance in this illustration, pushed the anterior communicating artery complex and the optic tractus backward. The olfactory tractus was pushed laterally, skirting around the tumor.

Superior interhemispheric approach:

It requires minimal unilateral retraction of the frontal lobe and no elevation from the orbital roof in comparison with the subfrontal approaches. The upward retraction of the frontal lobe determines the risk of sectioning, avulsion, or creating an ischemic lesion on the olfactory nerves, and must be limited to 1.5 cm [209; 210; 211]. Moreover, the trajectory of the superior interhemispheric approach is located far away from the olfactory tractus because the trajectory line is located under the genu of the corpus callosum. Superior interhemispheric

approach decreases surgical risk to the microvasculature. Careful dissection of the anterior communicating artery complex and its branches can be achieved by good visualization of the posterior aspect of the tumor. Performed at an early stage of the operative period, this dissection permits one to cut the microvessels from the anterior cerebral artery to the meningioma and to selectively dissect the encased anterior cerebral artery and its branches. The optic pathways are supplied to their inferior surface by microvessels arising from the superior hypophyseal arteries. subsequently, a microdissection using a superior interhemispheric approach, preserving the microvasculature lying on the arachnoidal membrane on the inferior surface of optic pathways, contributes to minimizing the risk of postoperative deterioration [208].

Superior interhemispheric approach is the orthogonal view of the cranial base allowing to treat both the extension to the posterior part of the optic pathways and the dural insertion of the meningioma. The meningioma extension into both optic canals might be explored after sectioning of the falciform ligaments. Furthermore, the superior interhemispheric approach provides access to both sides of the dihedral space between the medial face of the ICA and optic nerve under the anterior clinoid process. Finally, this superior interhemispheric approach allows for the preservation of the pituitary stalk up to the sellae diaphragm [208]. The disadvantages inherent to the interhemispheric approach are essentially related to the initial dissection of the interhemispheric fissure. The injury to the venous drainage system such as a thrombosis of the superior sagittal sinus or the bridging veins may occur, especially at the beginning of the intervention.

1.2.2. Laterosellar meningiomas:

1.2.2.1. *Cavernous sinus meningioma:* [212]

Technical advances in skull base surgery have established the cavernous sinus as an approachable space whose contents may be navigated successfully during meningioma surgery. Core principles of these approaches include maximal bone removal for exposure; the avoidance of brain retraction; and control of the carotid artery in its petrous, cavernous, and clinoid segments. During tumor resection, arachnoid planes facilitate tumor removal, but these planes become scarred and obliterated after prior resection or irradiation, emphasizing

the importance of extensive resection during the initial operation. If necessary, when no arachnoidal plane is encountered, small remnants of adherent tumor are left on the carotid artery. The same management is performed regarding the cranial nerves. Attempts should be made to remove all affected dura, and any affected dura that cannot be resected should be electrocoagulated, if possible.

The most performed surgical approach to the cavernous sinus is the cranioorbitozygomatic (COZ) approach.

The COZ approach affords wide exposure of the entire cavernous sinus, including the proximal and distal carotid artery, with minimal cerebral retraction.

1.2.2.2. Posterior clinoid process:

Several approaches have been used to access this region, and many of these represent variations of the classical pterional, subtemporal, or presigmoid routes with some modifications in bone resection. In this situation, some approaches, such as fronto-temporal (FT) or FT plus orbitozygomatic (FTOZ), transzygomatic subtemporal, presigmoidal transpetrosal, and combination of FTOZ and combined petrosal, are described as the surgical approaches for PCP meningiomas (**See table 55**) [213]. The key issues in PCP meningioma surgery are preservation of the perforators and optic nerve. To achieve these, the important steps for larger tumors are:

- ❖ Devascularization and debulking of the tumor ;
- ❖ Unlocking the optic nerve by anterior clinoidectomy and dissection the falciform ligament.

In the frontotemporal and pterional approach, there is direct access to the tumor through the optico-carotid and carotico-oculomotor corridors, but the perforators, which are pushed anteriorly by the tumor, are at risk of injury or vasospasm. This is the main difference from ACP meningiomas. On the other hand, lateral routes through subtemporal and transzygomatic approaches would be a better choice for early devascularization and debulking, which allows for direct access to the PCP between the third nerve and P-com arteries after resection of small compartment around these structures. During this early step, injury to the perforators would be minimized. However, anterior extension of the tumor

through the prechiasmatic or carotid cistern would be behind the perforators, decompression of the optic canal would be also difficult. Posterior transpetrosal approach, which is rarely selected for retrochiasmatic extremely large and firm craniopharyngiomas, is another choice to avoid perforator injuries. Though this allows easier access to the large superior extension, elevating the third ventricle, resection of the anterior extension of the tumor, and optic canal decompression are difficult similar to a subtemporal approach. Considering these, FTOZ would be the best for early optic canal decompression via a transsylvian route, and devascularization-debulking of the tumor via an anterior temporal or subtemporal route.

Thereafter, devascularized tumor removal through windows among the perforators would minimize perforator injuries;. During these procedures, monitoring of MEP would be required as blood flow reductions from retraction may result in small infarctions even without significant perforator. For extremely large and firm tumors extending superiorly, a posterior transpetrosal approach might be recommended for the first stage combined with a FT transsylvian approach for devascularized residual tumor during the second stage. Further studies regarding the management of PCP meningiomas including surgical indication will be needed to establish its management strategy [214; 213].

Approaches	DISADVANTAGES
Frontotemporal approach	More anterior temporal lobe retraction and surgical decompression of the tumour in between critical blood vessels and oculomotor nerves, posing an increased risk of injury to these structures.
The transzygomatic subtemporal approach	Retraction of temporal lobe which can result in contusion, and occasionally venous infarct, which can be avoided by placing a lumbar drain preoperatively

TABLE 55 DISADVANTAGES OF DIFFERENT APPROACHES IN PCPS

We selected the frontotemoporal approach for resection of tumor in our case as we were more experienced with using this approach for other pathologies in the same region.

1.2.3. Sphenoid wings meningiomas:

1.2.3.1. Lesser sphenoid wing:

Lateral sphenoid wing [121]:

Surgery for lateral wing tumors aims at the complete removal of the tumor and excision of its dural origin, including a safety margin. Large tumor may encroach upon the superior orbital fissure or the cavernous sinus, which will preclude a truly radical resection. A frontotemporal craniotomy is the most performed approach exposing the tumor and also any part of the dura invaded by the meningioma (**See fig. 45**). The pterion is drilled as required. A carefully executed craniotomy provides early control of the tumor's main blood supply through dural and pterional branches of the external carotid meningeal artery. The dura is incised in a circumferential manner starting laterally. This results in further devascularization. It may be helpful not to excise the mediobasal dura at this stage of the operation, even if it is involved by the tumor, to prevent undue epidural oozing into the surgical field. Removal of the tumor will often start with internal decompression. Small to medium-sized tumors may not require initial debulking [121].

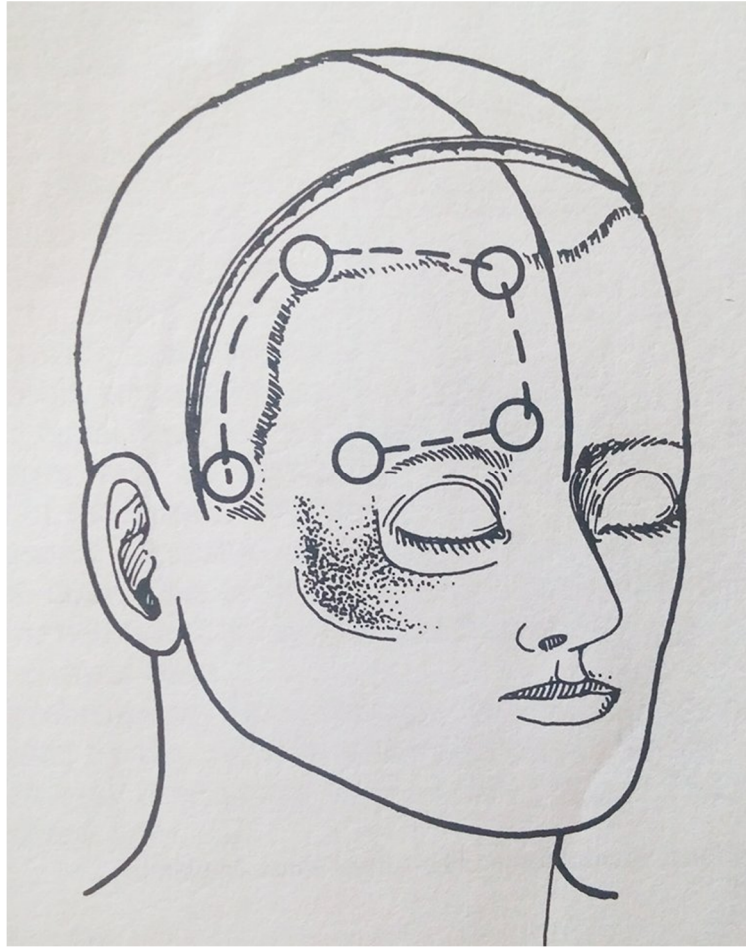


FIGURE 45 FRONTOTEMPORAL APPROACH THROUGH A SUBCORONAL INCISION [11].

The borders of the tumor are dissected in a systematic way. The main issue at this step is the identification and preservation of the distal branches of the middle cerebral artery. Major branches of the middle cerebral artery and sometimes the main trunk itself may be engulfed by the tumor, but true invasion of the wall of the middle cerebral artery is very rare. Identifying the distal branches of the middle cerebral artery and following them around or through the tumor is necessary, this has proven much easier than attempting to dissect the proximal middle cerebral artery when there is still a substantial bulky tumor nodule left in the surgical field.

A sharp scalpel can be very useful at this stage of the operation. One has to keep in mind that it is possible to tear the walls of major vessels, including the middle cerebral and the internal carotid artery, with the ultrasonic aspirator.

Middle sphenoid wing meningioma [121]:

Concepts of surgery for lateral wing tumors can be applied to operations for middle sphenoid wing meningiomas as well. Meningiomas of the middle sphenoid wing are generally operated through a pterional craniotomy providing access to the orbital roof and the base of the middle fossa as necessary. Some middle ridge tumors may involve the anterior clinoid process and the optic canal. Extradural clinoidectomy and unroofing of the optic canal have been advocated for such cases to prevent additional damage to an already compromised optic apparatus during the intradural dissection [215]. Some authors find that extensive extradural drilling may even increase the risk for optic nerve damage due to the retraction necessary for these maneuvers.

The large arteries of the anterior circulation may be engulfed by large tumors, involving the medial sphenoid wing. In such cases, early visualization of the internal carotid artery is sometimes impossible. After the large tumor bulk has been removed, it is often possible to expose the hidden proximal carotid artery from a subfrontal route and to dissect the remaining tumor away from the vessel, alternating between a proximal and a distal/lateral approach. Large tumors may encroach upon the optic apparatus. Developing proper (arachnoidal) dissection planes is very important. Inappropriate retraction, tearing of feeding vessels and even bipolar coagulation in the vicinity of an already impaired optic nerve or chiasm can result in further deterioration [121].

Anterior Clinoid meningioma [119; 120]:

Removal of anterior clinoidal meningioma is best achieved with a wide frontoorbital craniotomy. Other names used for this craniotomy are extended pterional approach or extended pretemporal approach. In addition the craniotomy should include a very low threshold to include the orbital roof in the craniotomy flap (cranioorbitozygomatic approach)

to be able to access the suprasellar extension of these tumors without the need of excessive frontal lobe retraction. Once the craniotomy is established, the extradural work is proceeded that leads to the removal of the anterior clinoid process, this extradural work will help expose the clinoidal internal carotid artery segment and later exposure of the sylvian fissure arterial branches will provide the two normal ends of the vascular tree, which can then be dissected proximally and distally as the tumor is being resected. Once the extradural work is done, debulking of the tumor is started with intermittent dissection of the tumor away from the adjacent brain and blood vessel using the curettes, scissors, bipolar coagulation, the ultrasonic aspirator, or the carbon dioxide laser. Once this is achieved and the course of the different arterial branches is visualized, final tumor removal is performed. The site of dural implantation is identified, and the tumor's feeding vessels are coagulated. The underlying bone, which has partially been removed during the extradural removal of the anterior clinoid process, is further drilled and resected with a high-speed diamond drill and copious irrigation aiming at as complete resection as possible and at the same time achieving bone hemostasis. As part of the process of removing the anterior clinoid, the optic canal is decompressed by removing the optic strut and the optic roof. The dural layer over the optic canal is opened along the optic nerve. This allows access to tumor extending into the optic canal. The tumor is followed along its extension into the orbit. Extra caution is taken while dissecting the optic nerve to preserve the very small blood vessels providing blood supply to the optic canal from the superior hypophyseal branches. It is also important to pay attention to the fact that occasionally direct arterial supply from the ophthalmic artery close to its origin may inadvertently be injured. This can best be avoided by careful dissection with magnification and with the anatomical knowledge of those vessels.

In tumors that extend further laterally, the dissection of the temporal dura away from the lateral wall of the cavernous sinus may be extended to a more posterior point to remove tumor extending into the region of the cavernous sinus. In tumors with extensions toward the suprasellar and subchiasmatic regions, it is important that the dural ring around the internal carotid artery be dissected to widen the space between the internal carotid artery and the optic nerve to gain access to the tumor segments extending into the subchiasmatic and possibly retrochiasmatic region. Occasionally these tumors extend more posteriorly along the tentorial

edge and compress the third nerve inferiorly. The third nerve can be identified extradurally at the level of the superior orbital fissure and followed from its extradural to its intradural segments under full visualization to mobilize and avoid its injury during tumor resection.

Gross total resection should always be the goal of surgery. However, in tumors where there is no arachnoid layer to separate the tumor from the wall of the internal carotid and its branches, good judgment is exercised to decide the extent of tumor resection to avoid injury to adherent vessels and to avoid additional morbidity.

Once the appropriate degree of resection is achieved, the reconstruction of the skull base is carefully attended to. The dural defect is reconstructed with dural replacement materials.

1.2.3.2. Greater sphenoid wing : [216]

The resection of greater sphenoid wing meningiomas is the same as the middle and lateral sphenoid wing meningiomas. The approach mostly used in this location is a pterional approach.

1.2.4. Sphenoorbital meningioma:

Sphenoorbital meningiomas have some distinctive features that might make surgery more challenging. Removing hypertrophied sphenoid bone severely narrowing various foramina requires a methodological drilling technique. Despite the development of advanced skull base techniques, aggressive removal of SOMs with significant bony invasion is still fraught with difficulties.

The surgical approach may depend on SOM localization. In fact, inferomedial tumors, orbital apex tumors, and diffuse tumors should be approached via a supraorbital-pterional approach, whereas lateral tumors should be treated with lateral orbitotomy including removal of the sphenoid wing and lateral orbital wall [217]. When using the supraorbital-pterional approach, the first surgical steps are entirely extradural and involve drilling of the lesser sphenoid wing down to the superior orbital fissure and the lateral orbital wall. Then the optic canal is unroofed extradurally. If the periorbita is infiltrated, it is removed as extensively as

possible. If there is infiltration of the extraocular muscles, only the exophytic tumor is removed.

The unroofing of the optic canal via a cranioorbital approach should be performed in almost all cases of SOMs with visual dysfunction, except for lateral SOMs where the involvement of the roof of the optic canal is rare [218]. Instead, lateral SOMs that invade the lateral or superolateral compartments of the orbit may be successfully managed and removed through a lateral orbitotomy with resection of the sphenoid wing and without craniotomy [219]. The extent of the craniectomy and the size of the craniotomy are “right-sized” intraoperatively based on feedback from CT and MRI coregistered stereotactic navigational data, as we have discussed in the neuronavigation chapter.

If more extensive dural or orbital exposure is necessary, a frontotemporal craniotomy can be elevated. All hyperostotic bone of the lesser sphenoid wing, middle fossa floor, lateral orbital wall, orbital roof, and anterior clinoid process is removed extradurally using a high-speed drill under magnification and constant irrigation. As the lesser sphenoid wing and anterior clinoid are removed, the optic canal and upper part of the SOF are opened. The foramen ovale and rotundum are opened as the floor of the hyperostotic middle fossa is removed.

Intradural tumor involvement is removed with sharp dissection and microscopic techniques.

Dural resection is extended to include the medial temporal dura of the lateral cavernous sinus wall if necessary.

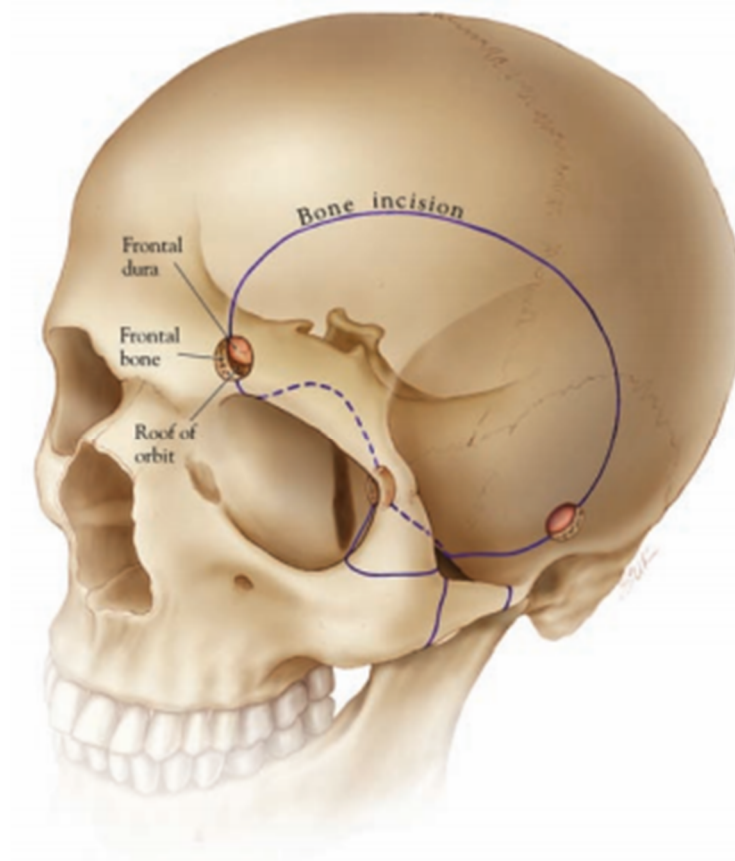


FIGURE 46 ORBITOCRANIAL ZYGOMATIC APPROACH [10]

Meningioma extension within the cavernous sinus and SOF can directly invade the cranial nerves and the connective tissue planes between the cranial nerves and is typically left in place to avoid neurological complications. Once the intracranial portion of the tumor has been excised, attention is turned to the intraorbital involvement. The dura is repaired with pericranium, temporalis fascia, or allograft material before the initiation of intraorbital tumor resection. Often, tumor extension into the orbit is extraconal and extraperiorbital. This extent is removed when the bone of the lateral orbit is removed. When involved, the periorbita is resected, and intraorbital tumor invasion is removed. All intraorbital, extraconal tumor can be removed. Invasion into the orbital apex, annulus of Zinn, or SOF is left in place due to the high risk of injury to the cranial nerves. If the sphenoid or ethmoid sinuses are entered, these are obturated with autologous fat graft to prevent cerebrospinal fluid (CSF) leakage. If a periorbital defect is present, it is closed with locally harvested temporalis fascia. The

pericranial graft is then rotated over the orbit. This helps to compartmentalize the orbit from the intracranial space and to avoid adhesion of the orbital tissues to the dura.

Bony reconstruction of the orbital walls and sphenoid ridge is not necessary for achieving a good cosmetic result if the periorbita is intact or repaired. If the superior or lateral orbital rim is removed, it can be reconstructed with split calvarial bone grafts or commercially available orbital prostheses. The orbital and zygomatic osteotomies are fixated with low-profile cranial plating. Remaining dead space from hyperostotic bone removal can be filled with autologous fat graft. If a temporal fossa defect exists, a cranioplasty is performed.

Conclusion:

Positioning of patient, well planned incision are the first important things to perform carefully. The 4 main steps of meningiomas are: DDDD

D: Dedress

D: Devascularization

D: debulk

D: dissect

Tumor resection start with an early interruption of blood supply which gives a better chance of managing surgery efficiently. An early relaxation to make the above maneuvers more feasible is the most critical part of the meningioma surgery along the skull base.

Adequate bone work that requires a skull based approach, head elevation, lumbar brain most importantly are necessary to avoid morbidity.

The dissection has to be careful with a minimizing of frontal lobe retraction. Visualization of the main neurovascular structures is very important with an early decompression of the optic canals if involved as well as a meticulous handling of adjacent structures using microforceps to dissect arachnoid membranes from the cranial nerves and sharp dissection to separate the vessels.

5. Excision quality:

Skull base meningiomas are very challenging lesions in quest for total removal. Meningiomas, as a benign tumor, are amenable to surgical cure and this should be the aim of their management. Complete removal of a meningioma, Simpson grade I, offers a cure in more than 90% of cases [220; 221]. Not every meningioma can be removed totally, and the surgeon is forced in some cases to accept residual tumor. In pursuing safe removal of meningiomas, surgery provides elimination of the tumor but also contributes to the preservation of neurological function and high quality of life. Thus, near total removal is well accepted as a deliberated choice knowing that other options are available such as radiosurgery for small residual to move.

I	Macroscopically complete tumor removal with excision of dural attachment and abnormal bone; including sinus resection when involved
II	Macroscopically complete tumor removal with coagulation (Bovie electrocautery or laser) of dural attachment
III	Macroscopically complete tumor removal without resection or coagulation of dural attachment or of its extradural extensions (e.g., hyperostotic bone)
VI	Partial tumor removal
V	Simple decompression (with or without biopsy)

TABLE 56 SIMPSON GRADING SCALE FOR REMOVAL OF MENINGIOMAS

6. Application of endoscopy in the management of anterior and skull base meningiomas:

The surgical technique of the EEA for anterior skull base tumors has been described in detail [222; 223; 224; 101; 225; 226; 227; 228; 229]. Important advantages of EES such as lack of brain retraction, fast recovery, avoidance of cutaneous incisions with excellent cosmetic result, and shorter surgical time and hospital stay have been described.

OGMs: [230; 231]

Olfactory groove meningiomas are typically very amenable to endonasal approaches. Located above the cribriform plate, a rostral extension of the basic endonasal approach involves removal of the ethmoidal air sinuses. The cribriform plate and crista galli are then removed to expose the dura of the midline anterior cranial fossa floor. This provides a wide bilateral working space extending from the frontal sinus anteriorly to the planum sphenoidale posteriorly and laterally to the superomedial wall of the orbits.

This approach allows the anterior and posterior ethmoidal arteries to be coagulated before durotomy and debulking, which in turn assists in devascularizing the tumor. The basic tenets of microsurgical removal of tumors apply to endoscopy. After initial internal debulking, the edges of the tumor are defined. A plane between tumor capsule and normal brain is then identified, developed, and maintained as far as possible. With large tumors that extend posteriorly to the planum and beyond, extreme care needs to be taken when dissecting the dome and posterior wall of the tumor because branches of the anterior cerebral artery may be intimately involved. At no time should the capsule of the tumor be pulled without direct visual confirmation that surrounding neurovascular structures are no longer attached.

suprasellar meningiomas [230]:

There are several inherent advantages of the EEA. All abnormal bone underlying the tumor is removed during the approach. Although hyperostotic bone deformities may camouflage the anatomical landmarks of the skull base (sella, carotid protuberance, optic protuberance, medial and lateral opticocarotid recess, tuberculum sellae, and planum sphenoidale), the use of image guidance can prevent disorientation and provide precision in defining the bony boundaries. When involved, the posterior ethmoidal arteries and other parasellar meningeal vessels can be identified and coagulated. This direct approach from below facilitates an early devascularization of tuberculum and planum meningiomas, resulting in an almost bloodless intracranial tumor removal, and facilitates complete resection of the sellar dural diaphragm where tuberculum sellae meningiomas may attach.

VII- Pathology:

As a group, meningiomas probably display the greatest variety of patterns of any primary brain tumor (See **table 57**), which sometimes poses diagnostic challenges. The three most common histologic subtypes are the meningothelial (syncytial), transitional, and fibroblastic meningiomas; however, meningiomas may display more than one histologic pattern in a tumor. According to WHO criteria, meningiomas are designated as benign (grade I), atypical (grade II), or anaplastic/malignant (grade III). The following sections briefly describe the morphological subtypes associated with each grade [232; 233].

Type	Grade
Meningothelial meningioma	WHO grade I
Fibrous (fibroblastic) meningioma	WHO grade I
Transitional (mixed) meningioma	WHO grade I
Psammomatous meningioma	WHO grade I
Microcystic meningioma	WHO grade I
Secretory meningioma	WHO grade I
Lymphoplasmacyte-rich meningioma	WHO grade I
Metaplastic meningioma	WHO grade I
Chordoid meningioma	WHO grade II
Clear cell meningioma	WHO grade II
Atypical meningioma	WHO grade II
Papillary meningioma	WHO grade III
Rhabdoid meningioma	WHO grade III
Anaplastic (malignant) meningioma	WHO grade III

TABLE 57 WHO CLASSIFICATION OF MENINGIOMAS

A.Grades:

1. WHO Grade I:

Meningothelial: This variant of meningioma exhibits a syncytial growth pattern and is composed of polygonal cells with abundant eosinophilic cytoplasm and indistinct cell borders. A diagnostically useful cytologic feature is the presence of nuclear pseudoinclusions or clear nuclear vacuoles.

Fibrous: As its name suggests the predominant cell shape is spindled, with the tumor composed of fascicles of interlacing bundles of slender elongated cellular elements. Although most meningiomas are reticulin-poor, a rich reticulin and collagen network is found between cells in this variant. Occasional psammoma bodies may also be evident.

Transitional: They are a mixture of the meningothelial and fibrous types [234].

Microcystic: Also known as humid or vacuolated meningioma, is a relatively uncommon variant. They are composed of loosely arranged clusters of cells with long, thin processes containing variably sized intercellular vacuoles that either appear empty or contain pale mucinous material, xanthomatous cells, and hyalinized blood vessels.

Psammomatous: Some view the psammomatous variant of meningioma as a type of transitional meningioma. This variant, however, is still separated from the other types. Psammomatous meningiomas contain many psammoma bodies to the extent that in extreme examples only sparse remnants of tumor cells are present in highly calcified examples. Psammoma bodies themselves are made up primarily of calcium material arranged in a concentric arrangement, collagen fibrils, and small amounts of iron.. Bone-related proteins, including osteopontin produced by CD68-positive macrophages, are thought to play a role in psammoma body formation [235].

Secretory: They are typically meningothelial or transitional lesions in which epithelial differentiation has produced intracellular lumina. This variant is distinguished by eosinophilic globular hyaline inclusions that are intensely periodic acid–Schiff (PAS) positive and diastase resistant, which have been termed pseudopsammoma bodies. The tumor cells are carcinoembryonic antigen (CEA) and cytokeratin positive while the luminal secretions are CEA positive. Blood CEA levels can be monitored to follow tumor recurrence. Many of these tumors are also marked by the presence of prominent peritumoral edema [236; 237].

Angiomatous: The designation of angiomatous meningioma is specifically used for tumors in which numerous blood vessels are present and appear to represent the predominant background pattern of the tumor [238].

Metaplastic: They are meningothelial, fibrous, or transitional with metaplastic changes that may include, Some of these histologic variants have been historically associated with increased recurrence or more aggressive behavior, although they are, as a group, still designated as grade I tumors

Lymphoplasmacyte-Rich: They are typically a meningothelial, fibrous, or transitional meningioma accompanied by a variable chronic inflammatory infiltrate [239].

2. WHO Grade II

Atypical Meningioma: is a designation used for tumors that are marked by the presence of certain histologic parameters which have been associated with more aggressive behavior, increased association with recurrence, and a small risk of distant metastasis, The most recent rendition of WHO uses the designation of atypical meningioma to delineate tumors that are marked by the presence of four or more mitoses per 10 high-power fields (with a high power field defined as 0.16 mm²) . Alternatively, atypical meningioma may be characterized by the presence of three or more of the following histologic characteristics: increased cellularity, small cell change, i.e., cells with high nuclear-to-cytoplasmic ratio, prominent nucleolation,

and uninterrupted patternless or sheet-like growth pattern, and foci of spontaneous or geographic necrosis.

Clear Cell: this variant of meningioma is marked by prominence of tumor cells demonstrating abundant clear cytoplasm. Characteristically and diagnostically helpful, the cytoplasm stains positive for periodic acid-Schiff because of the presence of glycogen. Whorl formation is not well defined in this variant and psammoma bodies are not seen. Hyalinized blood vessels may be prominent in clear cell meningiomas. This tumor usually affects younger patients more often than other meningiomas.

Chordoid: they are characterized by chords of eosinophilic, epithelial, or spindle-shaped cells within a myxoid stroma, resembling chordoma [240; 241]. Variable numbers of lymphocytes and plasma cells characterize these tumors [242; 243].

3. WHO Grade III

Anaplastic:

Anaplastic or malignant meningioma has been clearly associated with poor survival (median survival < 2 years). These tumors are defined by WHO as “exhibiting histological features of frank malignancy far in excess of the abnormalities present in a typical meningioma.” . WHO further indicates that these features include either obviously malignant cytology (i.e., the tumor has an appearance similar to a carcinoma, melanoma, or sarcoma) or exceedingly high mitotic index (>20 MF/10 HPF) . Interestingly, the gender predominance that is observed with low-grade meningiomas in females is not evident with this grade of tumor. These tumors are not circumscribed like their lower grade counterparts and are frequently more difficult to excise. On the other hand, metastases also have, for the most part, been associated with anaplastic or malignant meningioma.

Papillary: They are marked by the presence of a focal papillary architectural pattern marked by fibrovascular cores lined by meningothelial cells. These tumors frequently demonstrate other morphologic evidence of more aggressive behavior, including other features typically

associated with aggressive behavior and they clearly show a propensity to focally recur and to metastasize [244].

Rhabdoid: They are uncommon, 25 Rhabdoid cells are recognized by their round eccentric nuclei, vesicular chromatin, prominent nucleoli, and abundant eosinophilic cytoplasm containing whorls of intermediate filaments. Similar to papillary meningiomas, this variant has been associated with increased risk of recurrence and distant metastasis [245; 246].

B. Immunohistochemistry

The role of immunohistochemistry in the diagnosis of the majority of meningiomas has traditionally been an ancillary one, primarily serving as a means of excluding other tumors that may bear a resemblance. There is no single immunohistochemical marker that is infallible in confirming the diagnosis. Most meningiomas have immunoreactivity for epithelial membrane antigen (EMA), making this a useful marker in separating meningiomas from other tumors [247]. With the exception of fibrous meningiomas, only weak and focal immunoreactivity for S-100 protein is seen. Slightly more than half of meningiomas express progesterone receptors, whereas the estrogen receptor status is usually negative. Keratins are known to be expressed in meningiomas [248], but unlike in carcinoma, staining is focal or patchy in meningiomas. more recently, claudin-1, a novel immunostain, has been shown to be useful in distinguishing meningiomas from histologic mimics. Although the specificity of this marker appears to be high, the sensitivity is low, which suggests that its utility is greater when used in a panel of immunostains. It has been argued that the presence of hormone receptors, especially progesterone, may partially explain the greater incidence of meningiomas in females.

C. Differential Diagnosis [232; 233]

Problems in diagnosis are unlikely for anyone familiar with the characteristic picture of the more common variants of this tumor. Yet problems may arise when the pathologist is confronted with small specimens that may not be representative of the overall appearance of the tumor or with rare morphological variants that mimic other entities. Within WHO grades I and II, as noted earlier, fibrous meningiomas bear a close resemblance to peripheral nerve sheath tumors. Distinction of these two entities is more of an academic point because they share similar prognoses. Otherwise, a panel of immunohistochemical stains is helpful in separating these tumors. Angiomatous meningiomas may mimic the appearance of a vascular malformation or hemangioblastoma. In addition to being highly vascular, hemangioblastomas are lipid-rich tumors, which stain with fat stains such as Oil Red O or Sudan black. These stains can be performed rapidly during intraoperative consultation and may facilitate the exclusion of this consideration.

Occasionally, idiopathic hypertrophic pachymeningitis, plasma cell granuloma, or RosaiDorfman disease may masquerade as lymphoplasmacyterich meningioma. Once again, appropriate immunostains are helpful in interpreting these difficult cases. According to the WHO definition, anaplastic meningiomas (grade III) “resemble carcinoma, sarcoma, or melanoma, and hemangiopericytoma” which implies that these entities should be considered in the differential diagnosis. The diagnosis of meningioma is supported by the following immunohistochemistry profile: at least focal membranous positivity for EMA, positivity for vimentin, negativity for cytokeratin, and weak or negative staining for S-100 protein.

For papillary meningiomas, the histopathologic differential diagnosis includes metastatic papillary adenocarcinoma, papillary ependymoma, astroblastoma. Other tumors like choroid plexus papilloma may sometimes cause diagnostic confusion with a papillary meningioma.

VIII- Outcome:

A. Perioperative incidents:

1. Bleeding:

Meningiomas are highly vascularized and considered as the most hemorrhagic tumors [249]. Significant bleeding during surgery is a very frequent incident, it may cause negative effects on the perfusion and oxygenation of the brain [250], and it has a significant impact on surgical follow-up [251].

2. Blood pressure imbalance:

High blood pressure is a condition where the cerebral blood flow is increased, this could lead to the risk of vasogenic edema [252] ; unlike the hypotension which reduces cerebral perfusion, and may lead to cerebral ischemia. In order to prevent such incidents, the perioperative blood pressure should be kept stable. In our study, the second most frequent incident was blood pressure imbalance. The benefit of maintaining normovolemia and normotension during any intracranial intervention is now well established.

3. Disseminated intravascular coagulation (DIC) :

Occurrence of disseminated intravascular coagulopathies (DIC) during excision of cerebral tumors is possible [253]. Especially since immobilization, hydro- Electrolytes and haemoconcentration could cause significant clotting disorders which would lead to a deterioration of the patient's clinical condition [254].

4. Transfusion:

Meningiomas are hypervascular tumors whose vascularization is originating predominantly from the meningeal arteries (insertion pedicle) and the pterional arteries; this is the reason why they are known by an excessive bleeding during the operation and thus the use of a blood transfusion [74].

It was found that the early stages of surgery; skin incision and bone flap, were frequently performed by senior residents. It is not clear though if presence of senior surgeons would have led to less blood loss as it is well established that bony structures in meningiomas are hypertrophied and hypervascular.

Cataldi, in a series of 94 patients operated for meningiomas reported a transfusion incidence of 71% . Faihi in 30 cases of meningiomas found an incidence of 53.3%. Massous described in his study 12 among 20 patients that required intraoperative transfusion; An incidence of 60% . In our study, 75 % were transfused.

5. Cerebrospinal fluid derivation

Tumor excision cannot be performed in the presence of significant hydrocephalus. Thus a prior derivation of CSF may be necessary, it is not systematic but must always be discussed.

B. Morbidity :

1. Olfactory groove/orbital roof

Cerebrospinal fluid (CSF) leak, meningitis, hematoma, seizure, and visual worsening, are the most common procedure-specific complications, but occur infrequently in most series (See **table 58**). Some authors have found the bifrontal approach to be associated with more serious complications than other approaches, leading to their use of laterally based approaches [255; 256]. They recommend avoidance of bifrontal approach and of sectioning of the superior sagittal sinus [255]. We had no complication in the patient who underwent bifrontal approach, same findings in Gazzeri study [257] who found no increased cognitive deficits postoperatively in 35 bifrontal approaches for OGMs; in fact, many patients improved their cognitive function.

This table summarizes the most common postoperative complications encountered in OGMs, the visual loss is defined as a blindness that occurred in patients with preoperative normal vision. Therefore, the stationary both eyes blindness was not considered as complication. 5 patients with preoperative preblindness had blindness in both eyes. However

none of our patients had a visual loss with prior normal vision. We analyzed these complications in only 12 patients, the 2 remained patients died in the postoperative term.

Authors	Approach	n	Visual Loss (%)	Cerebrospinal Fluid Leak (%)	Infection (%)	Seizure (%)	Hematoma (%)
Hassler	Pt	11	0	0	0	0	0
El Gindi	BF	25	3 (12)	1 (4)	1 (4)	12 (48)	2 (8)
Nakamura	FL	34	0	2 (6)	1 (3)	4 (12)	1 (3)
	BF	46	1 (2)	2 (4)	0	2 (4)	5 (11)
Gazzeri	BF	36	1 (3)	2 (6)	0	1 (3)	0
Aguiar	Pt/BF	21	0	4 (19)	1 (5)	0	1 (5)
our series	SF, FT, Pt	12	0	0	0	0	0

TABLE 58 OLFACTORY GROOVE MENINGIOMAS AND OUTCOME [10]

The results of our series were very satisfying, the surgical outcome of patients with preoperative visual impairment or mental status changes related to these lesions is frequently satisfying; Nakamura et al. reported that preoperative visual disturbance improved in 55% of patients, dementia improved in 62.9% of patients, and concentration difficulties improved in 68.3% of patients [255], while Hentschel et al. reported a 100% rate of improvement of mental dysfunction and an 83% rate of improvement in visual disturbance [84]. Preservation of olfactory function was more likely in cases in which the tumor measured <3 cm in diameter and preoperative function was normal [258].

	Visual disturbance	Dementia	Concentration difficulties
Nakamura et al	55%	62.9%	68.3%
Hentschel et al	83%	-	100%
Our series	85%	-	100%

TABLE 59 IMPROVEMENT OUTCOME OF OGMS

One case of rhinorrhea was observed on postoperative morbidity in a patient with a large orbital roof meningiomas 7.5cm, that presented hemiplegia.

2. Suprasellar meningiomas:

Preservation of vision is the most important goal of surgery and improvement in vision has been reported in 40–80% of patients [93; 259; 260; 261]. Nakamura *et al.* reported 72 cases of tuberculum sellae meningiomas where total resection was achieved in 91.7% of the patients; Postoperative visual improvement was seen in 65% of the patients [262]. Visual improvement was dependent on the duration of preoperative visual symptoms, but not on the preoperative visual acuity or tumor size. Patients with visual symptoms of a duration <6 months tended to recover more often than those in which the duration of symptoms was longer than 1 year. We found in our study similar results; all patients with unchanged or worsened visual outcome have had visual symptoms of duration > 1 year. The possible reason is that compressive mechanical injury leads to small vessel compromise and demyelination, especially in patients with a long duration of visual decrease before surgery. In the study by Pamir *et al.* [263] peritumoral edema had a significantly worse visual outcome. It is correlated with a higher proliferative index and a higher angiogenetic activity [263]. Therefore, it may be speculated that the dismal visual outcome might be related to a higher growth rate and accelerated the course of nerve compression.

In the cohort series by Pamir *et al.* [263], an intact arachnoid plane could be identified in 83.33% of the patients and the visual outcome in patients with an intact arachnoid plane was significantly better than those, in whom no plane could be identified. The importance of this plane in achieving a safe resection has been stressed by several authors. Zevgaridis *et al.* [261] were the first group to show that its presence was also correlated with a better visual outcome. Early identification and preservation of the arachnoid anatomy facilitates easy dissection of the tumor from its surroundings and optic and chiasmatic vessels. Another factor is the arterial encasement by the tumor that has a direct impact on the complete resectability of the tumor, which in turn has significant influence on the visual outcome.

In PSMs patients of our series, 6% (n=2/34) worsened their vision, 20% (n=1/5) in TSMs, and 33% (n=1/3) in diaphragma sellae meningiomas. The overall rate of worsening vision is 9.5%. Other complications happened including, diabetes insipidus, infections, electrolytic disorder, rhinorrhea.

3. Cavernous sinus:

Most cavernous sinus meningiomas have intracavernous and extracavernous components: the latter can be surgically resected with a good outcome, while surgery for the intracavernous portion of the tumor, despite its feasibility, is associated with high morbidity, a low rate of complete resection [264; 265; 103; 108; 109]. The potential complications of cavernous sinus surgery for meningiomas include cranial nerve dysfunction, CSF leakage, stroke, hematoma, infection, and pituitary dysfunction,

Vascular Complications Stroke is a significant concern during cavernous sinus meningioma surgery, and fortunately reported rates of ischemic complications are low [266; 265; 267; 268]. One patient in our series recovered from a postoperative hemiparesis.

Cranial Nerves morbidity is a central issue in cavernous sinus meningioma surgery. The preponderance of evidence shows that existing preoperative cranial nerve deficits infrequently improve (10–14%) [264; 265; 103; 108; 109], and that few new permanent cranial nerve deficits appear postoperatively 12–41% . This concurred with our findings, all the patients in our series with CSMs having preoperative CN III deficit, have kept the deficit after surgery. Most series of aggressive surgical resection have reported that the majority of preoperative cranial neuropathies remain the same. None of our patients developed a new cranial nerve deficit after the surgery.

Series	No. Patients	New Cranial Nerve Deficits
Knosp et al [108]	29	CN III—14% . CN IV—14% CN VI—3.4%. CN V1—3.4% CN V2—10% . CN V3—17%
DeMonte et al [103]	41	10 in 7 (18%) patients
O’Sullivan et al [109]	39	23 (12% of 192 normal cranial nerves at risk)
Sindou et al [268]	100	CN III—29% . CN IV—15% CN VI—17% . CN V—24% (CN worsening)
Our series	4	None

TABLE 60 NEW CRANIAL NERVE DEFICIT IN CSMS BY AUTHORS

4. Posterior clinoid process:

Though the PCP meningiomas are rare tumors, their management can be extremely challenging. Due to their proximity to critical neural and vascular structures, serious postoperative neurological, endocrinological, and ophthalmological deficits may develop.

Series	Age	Surgical approach	Extent of excision	Complications
Goto et al. [269] (n = 5)	51,6 (45-58)	Presigmoidal transpetrosal 4 Combined transpetrosal and FTOZ 1	Total:4 Partial:1	none
Horiguchi et al. [113](n = 5)	NA	NA	Simpson grade 3 – 3 Simpson grade 4 – 2	Permanent hemiparesis – 2 Permanent cranial nerve palsy – 4 Thalamic dementia – 1
Ohba et al. [116] (n = 1)	60	Transzygomatic	Subtotal	Hemiparesis and hydrocephalus
D. Shukla et al [270]. n=2	50-41	Transzygomatic, subtemporal	Total – 1 Partial – 1	None – 1 Hemiparesis, hemianopsia, and partial oculomotor nerve palsy – 1
Our series n=1	48	FT	Total	Significant edema

TABLE 61 REPORTED CASES OF PCP MENINGIOMAS AND THEIR COMPLICATIONS

5. Lateral and middle sphenoid wing meningiomas:

Complication rate for these lesions is much lower than those of clinoidal meningiomas as we will discuss later.

Basso et al. reported the outcome of surgery for 23 middle and 59 lateral sphenoid wing meningiomas [271]. For the lateral sphenoid wing meningiomas, 89.8% of the patients had a good outcome with no sequelae, 8.5% had minor sequelae, 1.7% had major sequelae, while for the middle sphenoid wing meningiomas, 68.6% of the patients had a good outcome

with no sequelae, 26% had minor sequelae, 13% had major sequelae, Two recent American studies including 15,028 and 1281 patients, respectively, detail complication rates ranging from 4.5% to 16.5% [272; 273]. Operations for globular tumors of the middle and outer third of the sphenoid wing probably carry complication rates very similar to those for surgery for convexity tumors. Complication rates after surgery for lateral sphenoid wing meningiomas are higher. Visual deterioration, aphasia, and hemiparesis may occur in up to 5 to 10% of patients.

On the other hand, visual dysfunction may improve after surgery in 40 to 85% [274; 275; 276; 277]. Visual deterioration, new diplopia, and significant trigeminal symptoms may be seen in > 5 to 10% of patients [278; 279; 280; 127].

In our series, 25% (n=1/4) died after surgery. Visual dysfunction improved in all our patients.

6. Anterior clinoid process:

Among the most common morbidities after surgery of clinoidal meningiomas are those related to visual deterioration. The most common etiology is ischemic injury due to compromise of the blood supply to the optic apparatus. These complications are generally avoidable with a good knowledge of the normal as well as the pathological anatomy of these tumors. Ischemic complications resulting in major morbidities should be avoidable and usually occur at a very low rate after surgery of clinoidal meningiomas. Postoperative spinal fluid leakage is rare; however, it is not an uncommon complication and needs to be addressed by a good water-tight dura closure. In the presence of a satisfactory reconstructive repair recurrence of spinal fluid leakage can be addressed with lumbar drainage for 3 to 4 days. This complication occurred in 13% for our series, whereas other complications as hemiparesis in 2 patients, aphasia in one patient.

In general, anterior clinoidal meningiomas are best treated with surgical resection and, in the presence of advances in microsurgical technique, the majority of patients should benefit of a favorable long-term outcome.

Vision outcome is as follows: 21% with vision improvement , 36% with stationary blindness at both eyes, while one patient had a deteriorated vision up to blindness at both eyes with

previous functional vision status. This patient was the only one who underwent Simpson grade I resection.

In patients with type I tumors where significant adhesion between the tumor and the vasculature is encountered; the decision to leave some tumor behind to preserve function is more appropriate decision than attempting gross radical resection and increasing the risk of arterial injury and ischemia [281; 282].

Series	No. of Patients	% CS Involvement	Improvement of Vision%	Extent of Resection—%	Estimated Major Morbidity %
Al-Mefty 1990	24	38	8	Gross total—83	8
Lee et al, 2001	14	14	75	Gross total—87	0
Nakamura et al, 2006	108	64		Gross total—43	7,4
Pamir et al, 2008	43	2	85	Gross total—91	18,6
Bassiouni et al, 2009	106	29	40	Simpson grade I—II—59	17
Our series	14	NA	21	Simpson grade I, II, III, IV	57.14

TABLE 62 ANTERIOR CLINOIDAL MENINGIOMA MORBIDITY [120]

High rate of morbidity in this location is linked to depth of site of insertion and proximity to the internal carotid artery and optic nerves and chiasm.

7. Sphenoorbital (En plaque) meningiomas:

In modern case series, Temporary and permanent ptosis, diplopia, visual loss, facial palsy, hemiplegia, aphasia, and diabetes insipidus have been reported as neurological complications of surgery [127; 131; 134]. The most commonly reported postoperative cranial neuropathies are of the oculomotor, trochlear, and trigeminal nerves. Temporal hollowing, orbital dystopia, chemosis, CSF leakage, meningitis, osteomyelitis, retroorbital hematoma, epidural hematoma, and brain edema have also been described [134; 283; 127; 128].

As it is mentioned in the clinical chapter of SOM, the preoperative visual function is believed to be directly related to the degree of bone hyperostosis [284]. Complete removal of all involved hyperostotic bone and decompression of the optic nerve is crucial in ensuring postoperative recovery of function. Visual acuity in our series improved in 50% of patients.

So the question is, why some patients experienced improvement in their visual acuity while others did not? The reason is most probably related to the degree and period of optic nerve compression as it is the same as with TSMs [285; 286]. The combined intra- and extradural drilling of the optic nerve foramen and all of its bone compression is just as important as opening the optic nerve sheath and providing for release of the optic nerve [287] in its entire course intracranially to the orbit. Thus, the best prognostic indicators for optic nerve function postoperatively in SOMs are the degree of deterioration preoperatively and the total extent of decompression [287].

33% of our patients encountered postoperative complications such as: hemiparesis, aphasia, and infections.

C. Mortality:

Surgical morbidity and mortality have declined steadily as a result of refinement of microsurgical technique, advancement in neuroanesthesia, and improved perioperative intensive care.

1. Olfactory groove/roof of orbit meningiomas:

In the era of modern microsurgery, the surgical mortality associated with the resection of olfactory groove meningiomas has ranged from 0 to 17%, with most recent reports listing no deaths [288; 289; 290; 291]. Samii et al. reported 82 cases of olfactory groove meningiomas treated surgically ; the perioperative mortality rate has been reported to be 4.9%. In several series of patients, the operative mortality rate has also been low. In our series, there were 2 deaths in 14 patients.

Authors	Approach	N	Mortality (%)
Mayfrank	IH	15	0
El Gindi	BF	25	0
Obeid	BF/SF	15	0
Spektor	BF/Pt/SF	80	0
Nakamura	FL	34	0
	BF	46	4 (9)
Gazzeri	BF	36	1 (3)
Our series	SF/BF/FL	14	2 (14)

TABLE 63 MORTALITY OF OLFACTORY GROOVE MENINGIOMAS [288; 289; 290; 291]

In our series, no death occurred in roof of orbit meningiomas.

2. Suprasellar meningiomas:

Tuberculum sellae meningiomas present a special challenge owing to the vicinity to arteries of the anterior circulation, optic apparatus, and hypothalamus. The overall morbidity and mortality rates associated with the resection of these tumors have been observed to have decreased substantially in modern series. Total resection can be achieved in 76.4– 93% of cases with an incidence mortality of 0–8.7% [292; 93; 87; 90; 263; 293].

In our series, one patient committed suicide at 6 months after a major depression.

	Approach	n	Mortality (%)
Hassler	Pt	11	1(9)
Solero		98	17(17)
Tsikoudas	BF	13	2 (15)
Nakamura	FL	34	0
	BF	46	4 (9)
Gazzeri	BF	36	1 (3)
our series	SF/FT/	5	0

TABLE 64 TSMS MORTALITY BY AUTHORS [288; 289; 290; 291]

In planum sphenoidale meningiomas, 4 patients from 34 died after surgery, the mortality rate for our series is 11.76%, the main reasons are:

- Bilateral frontal ischemia,
- significant cerebral edema;
- Resistant meningitis,
- Severe pneumopathy,
- Excessive bleeding.

3. Cavernous sinus meningiomas

Surgery for cavernous sinus meningiomas was developed with enthusiasm back in the 1980s; however, total resection is only achieved in 20–76% of patients who undergo aggressive surgery using the cavernous sinus opening technique [264; 103; 265]. In addition, aggressive surgical removal of these tumors is associated with an increased incidence of morbidity and mortality and does not provide a better rate of tumor control, presumably due to frequent tumor infiltration of the cranial nerves and vessels within the cavernous sinus [294]. We adopted a partial resection policy followed by radiosurgery to minimize the risk of postoperative morbidity and mortality. No death was encountered in our series.

Series	No. Patients	mortality
Knosp et al [108]	29	3 (10%)
DeMonte et al [103]	41	6 (16%)
Sekhar et al [295]	114	0.8%
Our series	5	0

TABLE 65 MORTALITY IN CSMS REPORTED BY AUTHORS

4. Posterior clinoid process meningiomas:

Excision of these tumors requires a lot of surgical skills and experience. A good judgment on when to conclude the surgery is also important in order to avoid complications and postoperative mortality. The one patient in our series had an uneventful postoperative course.

5. Lateral and middle sphenoid wing meningiomas:

Mortality rate for these lesions is much lower than those of clinoidal meningiomas. Basso et al. reported the outcome of surgery for 23 middle and 59 lateral sphenoid wing meningiomas [271]. For the lateral sphenoid wing meningiomas, the mortality rate was 1.7%, while for the middle sphenoid wing meningiomas the mortality rate was 8.7%. In our series, no mortality was accounted in patients with middle sphenoid wing meningiomas, one death occurred in a patient with lateral sphenoid wing meningiomas from excessive bleeding. Of note, mortality is usually related to vascular injury with cerebral infarction or edema.

6. Anterior clinoid process meningiomas:

Substantial improvement in surgical outcome has been achieved in the last decade, and about 66% to 87% of these tumors can be totally resected with a 4–18% morbidity rate and zero mortality. In most series, mortality was zero [233; 296; 122]. In one series, one death has occurred. However, the anterior clinoid process remains surgically challenging lesions due to The frequent involvement of the optic apparatus, cranial nerves, cerebral vasculatures, and cavernous sinus.

Series	No. of Patients	% CS Involvement	Mortality(%)
Al-Mefty 1990	24	38	8
Puzzilli et al, 1999	33	39.4	15
Lee at al, 2001	14	14	0
Nakamura et al, 2006 19	108	64	0
Pamir et al, 2008 11	43	2	0
Bassiouni et al, 2009 6	106	29	1,9
our series	15	-	1

TABLE 66 RATE OF MORTALITY IN ACP MEINGIOMAS BY AUTHORS [233; 296; 122]

7. Greater sphenoid wing meningiomas:

2 patients died with greater sphenoid wing meningiomas, the reasons are the following:

- Hemorrhagic Shock

➤ Acute pulmonary edema

And one patient died 6 months after surgery, as he went through a major depression and committed suicide.

8. Spheoorbital (En plaque) meningioma:

In modern case series, perioperative mortality rates vary from 0 to 4%. Since 2001, two perioperative deaths have been reported, one from a pulmonary embolism and one from carotid laceration. In our series, 25% (n=2/8) died after surgery, one from hematoma, and other from significant postoperative edema with cerebral herniation.

Conclusion:

Dealing with meningiomas can be long, difficult, especially when the outcome is not satisfying for the patient, this includes all the permanent complications as a new deficit , a new cranial nerve deficit, a stationary blindness at both eyes , or worsened vision. Even though the patients are completely aware of all the upcoming and most probable postoperative complications, depression should be considered as one of the challenging postoperative outcomes and taken into account as a part of appropriate and comprehensive rehabilitation programs. That being said, as doctors, we must not neglect the consequences of depression on the patient daily life and we should know that a psychological follow-up is mandatory because it may help to overcome depression and the possibility of social isolation.

D. Recurrence:

Donald Simpson's often-cited report described meningioma recurrence rates based on the degree and description of the resection [220]. He reported a 9% recurrence rate after complete resection of the tumor and its neoplastic dural base, a 19% recurrence rate when the tumor was resected and the dural base only coagulated, a 29% recurrence rate when the tumor itself was removed but the dura could not be excised or cauterized, and an approximate 40% recurrence rate when only a subtotal resection was performed. In the modern era, even higher recurrence rates have been noted [297].

1. Olfactory groove/roof of orbit meningiomas

The recurrence rates for OGMs of 30% at 5 years and 41% at 10 years are often quoted in the literature [206]. This is probably due to the reluctance of some surgeons to aggressively resect involved tissues in the cranial base for fear of increased complications and difficulty of repair [83; 169; 298]. AlMefty and others have stated that failure to resect all involved tissues, including the bone and dura of the anterior cranial base, is the most significant factor that determines recurrence [299; 300; 288; 290; 298; 221]. Resection of the dural attachment, is also advocated as well as the removal of hyperostotic tumor-involved bone, and resection of any tumor entering the sinonasal and orbital cavities. Utilizing such an approach, recurrence rates less than 10% can be achieved [301; 257; 256]. In our series of 12 OGMs, complete resection including coagulation of the dural attachment was performed in 10 patients, one patient underwent complete resection including the hyperostotic bone and dura of the cribriform plate, in this series, 7% (n=1/14) recurrence was identified after a median follow-up of 5 years (range 1 to 13 years). The recurrence was observed in a patient operated twice, the first time the tumor was hemorrhagic and the Simpson was grade III, after one week, the second surgery was performed with total resection Simpson grade II. In 6 months on follow up, the recurrence was found in the same site, another surgery was performed, however the patient died after one year following his third surgery.

In their series of 15 patients with OGMs, including six recurrent tumors, Obeid and Al-Mefty noted a median of 8 years for tumor recurrence, with the most common site of recurrence being along the cranial base [290]. In that series, aggressive and complete resection was performed in all cases. At Henschel et al. series including 13 patients, complete resection including the hyperostotic bone and dura of the cribriform plate and any extension into the ethmoid sinuses was achieved in 11 patients and no recurrence was observed within a mean follow-up period of 2 years. Samii et al. reported 82 cases of olfactory groove meningiomas treated surgically [302]; gross total tumor resection was performed in 92% of cases, and the overall recurrence rate was 4.9% within a median follow-up period of 5.3 years. It has been reported that the cranial base and paranasal sinuses are sites with a predilection for recurrence of olfactory groove meningiomas [290].

In our series, no recurrence was observed in roof of orbit meningiomas.

2. Suprasellar meningiomas:

Tumor recurrence in TSMs is still common. One study demonstrated a 39% recurrence rate in a mean follow-up duration of 10.7 years [135]. Patients with tumor recurrence are likely to lose vision in at least one eye and are unlikely to experience visual improvement with subsequent surgery or radiation therapy.

Authors	No. of Patients	Surgical Approach	Recurrence Rate (%)
Fahlbusch & Schott, 2002	47	PT	4.2
Nakamura et al., 2006	72	BF, PT , FL	2.8
Rouen University Hospital study 2012	20	superior interhemispheric	0
Our series	5	SF , PT	0

TABLE 67 RECURRENCE RATE IN TSMS [208]

Unlike other series reported in literature, no recurrence was found in our patients with TSMs at a mean follow up period of 5years, excluding from these findings the patient who committed suicide at 6 months as he suffered a major depression, due to preblindness status not improved after surgery.

The recurrence rate for planum sphenoidale meningiomas in our series is 7%, even when gross total resection grade II was achieved. Therefore, postoperative patients should undergo long-term, serial clinical and radiological examination to allow early detection and management of recurrence.

3. Cavernous sinus meningiomas

Surgical resection of tumors within the cavernous sinus is not the prohibitive procedure it once was. Published series have established the technical feasibility of achieving gross total resection (GTR), and moreover have correlated extent of resection with rate of recurrence (See **table 68**). Two recent series described results with varying degrees of surgical resection.

GTR in one series was 92% when aggressive surgery was pursued, with a recurrence rate of 12.5% compared with 26% in subtotally resected cases [103]. This table shows tumor recurrence in different series. In our 5 patients underwent grade IV Simpson resection followed by radiosurgery, tumor control was achieved in 80% (4/5) and 20% (1/5) recurred at one year stressing the use of whole brain radiotherapy.

Series	No. Patients	Mean Follow-Up (Range)	Gross Total Resection	Tumor recurrence %
DeMonte et al [103]	41	45 mos (2 mos–10 yrs)	31 (82)	13
Heth and Al-Mefty	163	-	44 (63)	9
O’Sullivan et al	39	24 mos(6 mos–5.3 yrs)	8 (21)	5
Sindou et al	100	8.3 yrs (3–20 yrs)	12 (12)	11
Pichierri et al	24	9.7 yrs	22 (92)	12.5
Our series	5	1.5 yrs (6mos-13yrs)	0	20

Table 68 tumor recurrence after surgical resection of CSMs

4. Lateral and middle sphenoid wing meningiomas:

18.18% recurrence rate within 10 years in Basso et al series including 23 middle and 59 lateral sphenoid wing meningiomas [271]. Recurrence may arise from hyperostosis and osseous involvement of these tumors [279]. As the chance of total resection during a second surgery is low, every attempt should be made to achieve gross total resection, including the hyperostotic bone, during the first surgery [303]. No recurrence was found in our 3 patients who had a Simpson grade II resection.

5. Anterior clinoid process meningiomas: [120]

In our series, 27% (n=3/15) had a recurrence in a mean follow-up of 5 years. 14.28% (n=1/7) after a total resection Simpson grade II and 50% (n=13/6) after subtotal resection grade III and IV, excluding the patient who died by an excessive bleeding. The following table shows the overall recurrence in ACPMs.

Series	No	extent of Resection—%	Mean Follow-Up	Recurrence/ Progression Over all%
Al-Mefty 1990	24	Gross total—83	57 months	4
Nakamura et al, 2006	108	Gross total—43	6.59 years	23
Pamir et al, 2008	43	Gross total—91	39 months	9,3
Russell et al, 2008	35	Gross total—69	12.8 years	9
our series	15	Simpson I, II, III, IV	5 years	27

TABLE 69 RECCURENCE AFTER ANTERIOR CLINOIDAL MENINGIOMA RESECTION [120]

6. Spenoorbital (En plaque) meningiomas

Complete resection usually corresponding to a Simpson grade II resection has been reported in 33 to 83% of patients described in literature [127; 131; 260; 280]. In their series of 30 patients with SOM, Scarone et al, using the strictest criterion of a Simpson grade I resection, reported a zero rate of complete resection [304]. This highlights both the diffuse infiltrative nature of these tumors and the generally held philosophy of accepting a subtotal resection in the orbital apex, SOF, and cavernous sinus to preserve neural function.

Maroon et al, based on their experience with recurrent SOM, hypothesized reasons for recurrence as :

- Failure of early diagnosis of the tumor;
- Inadequate surgical resection due to the complicated neurovascular anatomy of the orbit, cavernous sinus, and SOF;
- Failure to appreciate that hyperostotic bone is indeed part of the neoplastic process;
- the biological behavioral tendency of these tumors to insinuate themselves into the foramina,; fissures, crevices, and interstices of the orbit, basal skull, and dura;
- the apprehension of surgeons that they will produce iatrogenic morbidity or mortality associated with a too-radical tumor resection [134].

Recurrence rates of 5 to 60% have been reported [127; 131; 128; 260; 305]. The majority of reports describe a greater incidence of tumor recurrence/progression in subtotally removed tumors [127; 128; 260; 305; 279]. Although some authors have found no difference

in tumor recurrence between patients who underwent complete resection and those that underwent incomplete resection [131; 306; 304]. The most common clinical sign in patients with recurrent SOM is progressive proptosis. Optic neuropathy is the most common cranial nerve deficit in patients with recurrence. In our series, 16.67% (n=1/6) had recurrence after Simpson grade IV resection in a mean follow up of 5 years excluding two patients who died within one month postoperative.

Conclusion:

Tumor recurrence or progression, similar to all other locations, is related to the extent of tumor resection during the first surgery. There is clear dependence on the extent of tumor resection as well as the length of follow-up. For this reason it is important to follow all patients with meningiomas for no less than a 10-year period after tumor resection before the patient is permanently discharged. There are some studies that suggest even continuing the follow-up up to 20 to 25 years after tumor resection.

IX- Prognosis:

It is important for neurosurgeons to appreciate the surgical outcome and quality of life after meningioma surgery. Outcomes are usually measured in surgical morbidity, mortality, time to recurrence, and quality of life.

The most common factors that influence *surgical outcome* include the comorbidity and age of the patient, the size and location of the tumor, and the presence and severity of neurological deficit. The measurable parameters for *patient outcome* include the Karnofsky performance scale (KPS) quality of life (QOL) assessments, biopsychosocial status, complication, and disease status. *Complications* include both surgical and medical complications. Surgical complications include infection, hemorrhage, cerebrospinal fluid (CSF) leakage, and wound problems. Medical complications include deep vein thrombosis, seizures, infection, and pulmonary embolism. *Surgical outcome* is reported in the form of extent of the resection, complications, morbidity, and mortality in most series. Factors that influence surgical outcome include tumor location, consistency, and vascularity; and the surgeon's experience, philosophy, and technique. It is apparent that surgical outcome and other treatment modalities influence *disease outcome*. This includes recurrence rate,

progression-free survival, and overall survival. This is related to the extent of resection, World Health Organization (WHO) grade of the tumor, and proliferative markers. Disease outcome is perhaps the greatest determinant of patient outcome; it is a compilation of all other factors. In this chapter, we will try to discuss all these features with details.

A. Prognostic factors related to the patient:

1. Age:

Current studies have proved that the age of the patient having meningiomas can be considered as a prognostic factor. Perioperative mortality rates in geriatrics range from 1.8% to 45%, and those of perioperative morbidity rank between 11.3% and 52%. However, some authors concluded that the morbidity and mortality rate of meningioma surgery in elderly patients is not significantly higher than that observed in younger patients [307; 308; 309].

In Boviatsis series [310], more complications were found in patients older than 65 years (20.4%), compared to patients under 65 years of age (11.7%). Mortality rate was 6.5% and 4.2% respectively, with no statistically significant difference. As a result, the increased incidence of complications in elderly patients did not affect the rate of mortality.

Advances in microsurgical technique, neuroimaging modalities, neuroanesthesia, and perioperative intensive care have improved surgical outcome substantially in recent decades, therefore, this has contributed to reduce morbidity and perioperative complications in elderly patients with meningiomas.

For many authors, age alone is not an impediment factor to neurosurgical intervention; unless there are other contraindications [309]. However, a careful preoperative clinical examination should be carried out, possible risk factors are to be properly managed and special attention is to be paid during the medication (corticosteroids, antibiotics, low molecular weight heparin, etc.) [310]. In our series, age was not found to be a significant prognosis factor.

2. Gender:

Several studies indicate that the incidence of atypical meningiomas is higher in male than in female [311; 312; 313; 314]. However, other studies reported that female is associated with higher recurrence or progression rate [314]. In our series, gender was not found to be as a significant factor.

3. Patient's history:

Sakho found [315] that two-thirds of the patients who died had ischemic heart disease, and in the study of Buhl [316; 236] including patients over 70 years of age, 63.62% had heart disease, 39.39% had hypertension, 30.30% had diabetes and 13.63% had malignancies. He found as a result, that the rate of morbidity and mortality is higher in patients with past medical history. For Arientia [317], diabetes seems to increase the mortality rate in her study.

Patients, who have already undergone intracranial surgery, appear to have a higher surgical risk and a worse outcome compared with those having for the first time a neurosurgical procedure [316]. This was confirmed by Djindjian study [318] where, in patients operated for the second time, 50% died within 30 days postoperatively. According to Bateman [319] and Goel [87], Comorbidity worsens the prognosis after surgery. Adequate preoperative management is required in patients with associated conditions including hypertension and diabetes. In our series, 14% had high blood pressure, 8% had diabetes. No correlation was found with postoperative morbi-mortality.

4. Preoperative status:

Neurological status:

Several series reported [320; 321; 322] that the preoperative deteriorated neurological status and the altered level of consciousness are associated with a higher rate of postoperative mortality [322].

Also, the Karnofsky Performance Status Scale (KPS) was taken into account as a factor of prognosis. Thus, Mastronardi [19] proved that patients with KPS <60 presented a higher rate of mortality and morbidity compared with those having KPS >60. In Czepko study [166], poor results were obtained in patients with KPS ≤ 40. Djindjian [318] found that the KPS <50 is associated with a poor prognosis. In other studies [322] a KPS <70 is a factor of poor prognosis. Same findings were observed in our series.

General status:

In Mastronardi studies [322], the rate of morbidity was higher in patients classified ASA III with a rate of 75% compared to 25% in patients ASA II. According to the same author, total removal of meningiomas should only be attempted in elderly patients when classified as ASA I or ASA II. In literature [320; 318; 323], the preoperative general condition (ASA III and ASA IV) is associated with higher rate of morbidity and mortality, however, it does not contraindicate neurosurgical intervention if alone [324].

B. Tumor features

1. Locations:

Particular sites in the skull base meningiomas were most notably associated with higher mortality and morbidity rate, as shown in Yamashita et al (the medial sphenoid wing, " middle fossa, and suprasellar meningiomas).

In literature, sphenoorbital meningiomas with involvement either intracranially or including the orbit, was also found to be associated with a higher risk of recurrence due to the higher rate compared with non-anterior visual pathway sites [325; 326].

According to papo [327] and cornu [320], a pejorative evolution is associated with sphenoid wing meningiomas. These results are consistent with those of the Jan series [328], for which the mortality rate is 31.5% for anterior clinoidal meningiomas . in our series, location was of a borderline significance.

2. Size:

Another prognostic factor that influences the progression free survival is the size of tumor. Alaywan [329] reported 44% unfavorable outcome for patients with meningioma superior than 6cm as opposite to 9% for tumor lesser than 3cm. Arienta [317] and Mastronardi [322] reported that all died patients had meningiomas up to 6cm. GarzonMuvdi et al [330] noticed that the rate of morbidity and mortality was higher in patients with a tumor size between 5cm and 10cm. Contrarily, other authors [320] [324]. did not find statistical significant influence for tumors greater than 4cm. in our series, tumor size >4.5cm were related with increased rate of morbi-mortality.

3. Perilesional edema:

More than 60% of meningiomas are surrounded by peri-tumoral edema [166]. It might cause mass effect and increased intracranial pressure, and has been considered to be associated with postoperative worsened outcome [317; 323]. we use preoperative corticosteroids to decrease edema.

According to Buhl's study [236], the less edema is, the better the results are. He found that patients who encountered worsened postoperative outcome had, 10% little or no edema, 33.33% moderate edema and 50% severe edema. Mattei [331] considered that severe cerebral edema would cause severe neurological deficit and limit the surgical field during surgery.

However, other authors [320; 322] did not find a relationship between the severity of peritumoral edema and postoperative mortality. We found that important perilesional edema was significantly correlated to morbi-mortality.

4. WHO grade:

Skull base meningiomas and tumors close to major venous sinuses were reported to have a high proliferative index and were associated with recurrence. [332; 333]. The proliferative activity of meningiomas is measured with Ki-67 labelling index (LI), it is considered as a potential instrument to establish the recurrence of meningiomas [334; 335;

336]. The Ki-67 index was proved in several studies as being the strongest distinguishing criterion between atypical and anaplastic meningioma [337].

Also, the immunohistochemical overstaining for MIB-1 antigen, CDK4, CDK6, p53, p16, p21, pRB protein, cyclin D1 and mitotic index were proved to be factors of prognostic, showing a statistically higher recurrence rate and also a shorter time of recurrence versus understaining. Among them, higher MIB-1 LI proved to be the strongest indicator for poor outcome. Also, it has been reported that tumor with mitosis closer to 20 per 10 highpower field, have more aggressive behavior compared with those of low mitosis. Osteopontin, a protein involved in tumour progression was proved to be correlated with poor clinical outcome and as prognostic factor [338]. We found that histopathology and morbi-mortality were co-dependent.

C. Surgery features:

1. Grade of excision :

Tumor removal should be as radical as is safe for the patient [339; 338], in Simpson's detailed analysis, the recurrence rate following total tumor removal and excision of dural attachment was 9%, compared with 19% after total tumor removal and cauterization of dural attachment. Partial tumor removal was followed by recurrences in 37% of 44 patients as compared to the 40% reported by Simpson. Turgut [340] and Mastronardi [322], report that the best results are obtained after complete resection. In the Kallio series [341], the relative risk of death is 4.2 times greater for patients whose resection is incomplete compared to complete resection. These results don't concur with Alaywan ones [74] who found that the mortality rate is elevated as the rate of complete resection is higher. We agree that incomplete resection leaves a persistent source of edema leading to increased rate of morbidity, and that aggressive resection per se is a source of complications in skull base meningiomas. We found no correlation between morbi-mortality and grade of excision.

2. Operative duration

The duration of the operative procedure was reported as being an important predictor of outcome in patients with meningiomas [324], Buhl [236] analyzed the correlation between duration of intervention and outcome: 89% of patients had good results for duration inferior to 4 hours as opposite to 9,09% for duration superior to 6 hours. Proust [324] considered that duration > 3 hours is a factor of poor prognosis. In overall, the shorter the duration of the intervention is, the better the results are.

3. Surgical experience and technique

Choice of approach depends on the neuroradiographic location and size of the tumor, the patient's health and presenting neurological deficits, the goal of total versus subtotal resection, and the surgeon's bias and level of experience.

Conclusion:

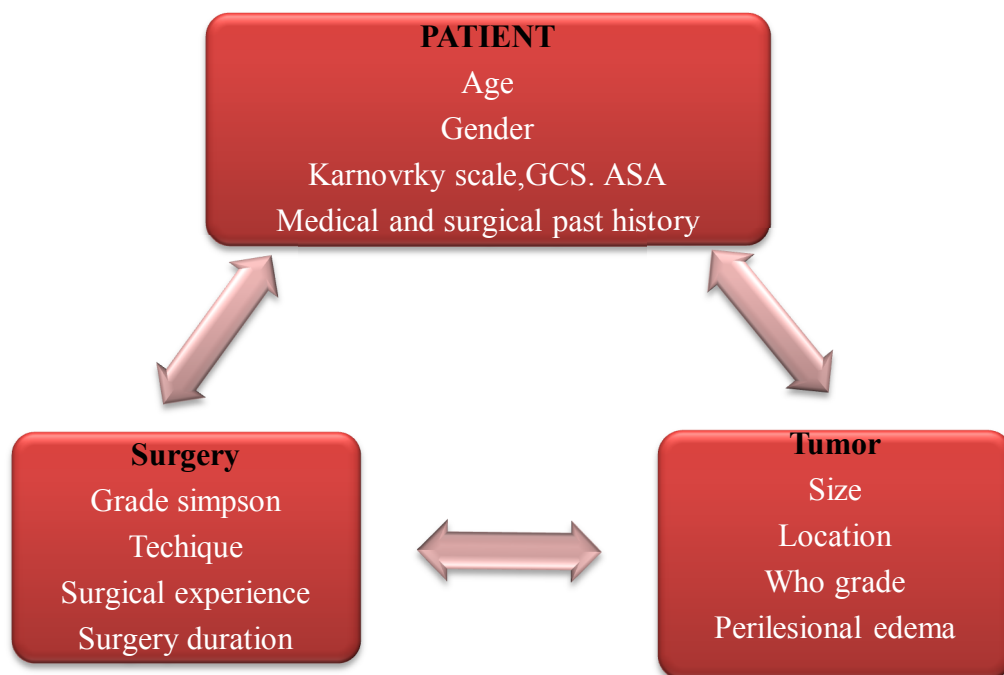


FIGURE 47 DIAGRAM SHOWING THE DIFFERENT PARAMETRS AFFECTING THE OUTCOME AFTER SURGERY FOR MENINGIOMAS.

X- Radiosurgery:

Stereotactic radiosurgery is predominantly delivered using one of two types of devices: the gamma knife or modified LINAC. The primary role of radiosurgery is to control small well-demarcated lesions while preserving the function of surrounding brain tissue and neighboring cranial nerves. As such, many skull base meningiomas are suitable for SRS, whereas open surgery in this region can be associated with a high risk of cranial nerve, brainstem, and vascular damage [342].

A. Indications for radiosurgery [343]:

Four main indications exist for which SRS may be considered as a primary or secondary treatment strategy for skull base meningiomas including patients unfit for surgery, small or residual cavernous sinus, and recurrent meningiomas. One benefit of SRS is that additional radiosurgery for the treatment of tumor recurrence can be offered without the additional risks of treatment-related morbidity.

	Treatment	Indications
Patients unfit for surgery	Primary	Elderly patients with preexisting conditions Patients unfit to receive general anesthesia
Small or residual meningioma	Primary Secondary	Small, neurologically asymptomatic (average diameter < 3 cm) Small, neurologically symptomatic (average diameter < 3 cm) Large (average diameter > 3 cm) Involvement of critical structures
Cavernous sinus meningioma	Primary	Holocavernous Cranial nerves, intracranial artery, or pituitary involvement
Recurrent meningioma	Primary	Recurrence or residual following aggressive resection

TABLE 70 RADIOSURGERY INDICATIONS IN ANTERIOR AND MIDDLE SKULL BASE MENINGIOMAS [343]

B. Morbidity of Radiosurgery [343] :

Different classes of cranial nerves have distinct tolerances for radiation. For instance, special sensory nerves (e.g, optic nerve) which is able to tolerate doses < 8 to 10 Gy with marginal risks, whereas somatic efferent nerves (e.g., the oculomotor nerve) can tolerate doses > 20 Gy.

Due to the tenuous nature of the optic apparatus and increased risks for neurologic injury associated with surgical resection, upfront SRS may provide superior vision preservation for meningiomas either involving or neighboring the optic apparatus.

Radiosurgery may be used to treat lesions within 2 mm of the optic apparatus after the tumor burden is reduced or as a standalone therapy if the unresected lesion is of similar size. Maximum radiation doses of 8 to 10 Gy are commonly used for the optic structures. However, with doses of 10 to 15 Gy, the incidence of radiation-induced optic neuropathy is as high as 26.7%, and at doses 15 Gy, the incidence rises to 77.8%.

Vascular complications following radiosurgery, including ischemia and hemorrhage, occur in 1.1 to 2.3% of cases.

Radiation doses > 25 Gy increase the risk of occlusion; hemorrhage likely results from vessel stress caused by rapid shrinkage of tumor postradiation. Stafford et al reported permanent neurologic deficits as a result of ICA injury (stenosis and occlusion) in 2 of 66 patients (3%) with cavernous sinus meningiomas treated by > 25 Gy SRS.³⁵ Vascular injury in the cavernous sinus is rare but has been reported to occur up to 60 months after treatment.³⁰

The most common adverse effect of SRS is edema as a result of brain invasion, venous congestion, blood–brain barrier breakdown, and release of inflammatory cytokines from damaged tumor cells after exposure to high doses of radiation.²³ Edema occurs more frequently with small meningiomas, whereas large tumors may be associated with edema if they are subjected to even low radiation doses.

The risk of radiosurgical failure is increased for tumors of higher World Health Organization grade and for those patients who have undergone prior surgery. Recurrent tumor growth after failed SRS, which can occur long periods (up to 14 years) after treatment, tends to be aggressive, and therefore it has been suggested that all patients should be followed

> 10 years after radiosurgery. The risk of radiation-induced tumors, especially in patients with benign lesions, is a potential but uncommon safety consideration. The risk for SRS for skull base meningiomas, however, is low (< 1 in 1000) due to the restricted volume of radiation exposure and small number of exposures. Malignant transformation after radiosurgery may more commonly result from the natural course of the disease rather than radiosurgery itself. After care of radiosurgical management of benign meningiomas should include surveillance with MRI at 6 and 12 months, and annually thereafter.

Patients who have had near-total resection are considered low risk for recurrence, and, as such, they may undergo imaging every 2 years after 5 years without recurrence. In our series, 26 patients underwent radiosurgery; no related morbi-mortality was recorded.

XI- Radiotherapy:

Radiation therapy implies multiple treatments, or “fractions,” given over time, as opposed to radiosurgery, which generally refers to a high dose of highly focused radiation given in a single fraction.

Its role has decreased in management of residual and recurrent meningiomas that are not amenable to radiosurgery. In general, radiation therapy given 5 days weekly over ~6 weeks yields a high probability of preventing further tumor growth with a relatively low risk of significant complications. This chapter discusses the indications for conformal radiotherapy, limitations and expectations, techniques, results, and complications.

A. Indications for radiotherapy: [344]

Surgical resection is the mainstay of treatment of meningiomas, but there are a variety of cases for which surgery alone may not be adequate treatment:

- Recurrent or multiple recurrent meningiomas after surgery, which are at high risk for further recurrence at shorter intervals .
- Malignant meningiomas, and perhaps also atypical meningiomas, which have a high risk of recurrence even after total resection .
- Extensive Meningiomas not amenable to curative resection.

In such cases, radiation therapy may be indicated, either as an alternative to surgical resection, postoperatively, or at the time of progression or recurrence after surgery.

The addition of postoperative radiotherapy to subtotal resection increases the progression-free survival probability to 78 to 91% at 5 to 10 years, comparable to the results of gross total resection alone [345; 346; 347].

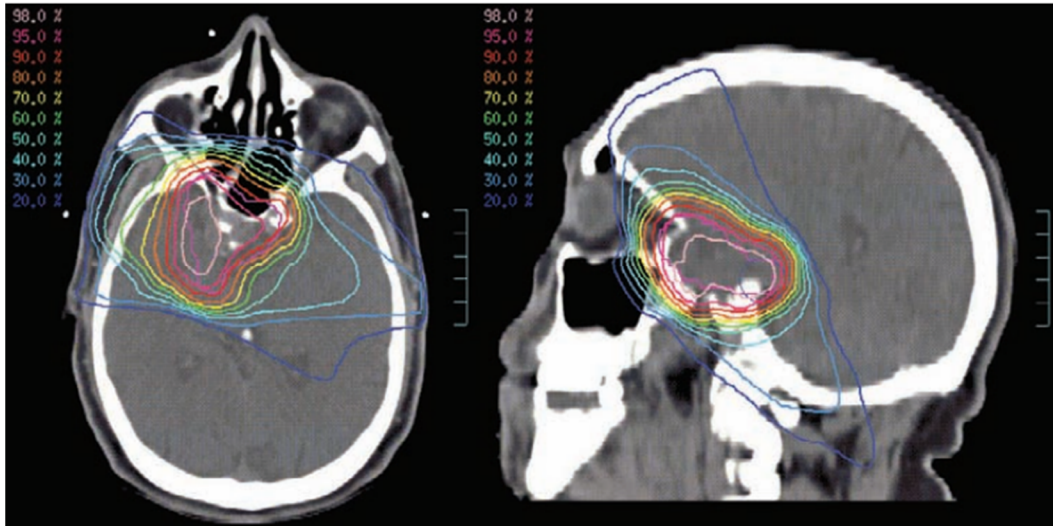


FIGURE 48 RADIOTHERAPY PLAN FOR A LARGE BENIGN MENINGIOMA IN THE RIGHT CS

[344]

B. Limitations and morbidity of Radiotherapy:

Although radiotherapy is generally successful at preventing further growth of benign meningiomas, it tends to result in little or no tumor shrinkage over time owing to underlying radiobiological principles. Rapidly dividing cells tend to die quickly after radiotherapy, resulting in marked tumor shrinkage or even complete disappearance of malignant tumors over weeks or months. In contrast, very slowly dividing cells may survive for many years after radiotherapy, resulting in little or no tumor shrinkage. Thus bulky benign tumors causing significant symptoms from mass effect may require surgical debulking, given that radiation therapy cannot be counted upon to reduce significant tumor mass effect in a timely manner. Over years after radiotherapy, ~20 to 30% of meningiomas shrink at least 2 mm in diameter or 25% by volume .

Cases of rapid, marked tumor shrinkage in the absence of histological verification should raise one's suspicion of a diagnosis of dural metastasis, hemangiopericytoma, or leiomyosarcoma, which typically shrink dramatically after radiosurgery or radiotherapy. On the other hand, visible tumor shrinkage is not necessary to see improvement in cranial nerve deficits; symptomatic improvement of cranial nerve deficits is relatively common after radiotherapy, despite the fact that there may be little or no visible tumor shrinkage. Papers containing detailed reports of symptomatology before and after radiotherapy describe improvement in 50 to 81% of symptoms, including cranial neuropathies [348] and clinical improvement in 43% of patients) [349; 350; 351; 106]. This is particularly relevant for cavernous sinus meningiomas and optic nerve sheath meningiomas.

Another important major limitation of radiotherapy is that it can generally only be given once to the same area without inducing major risks of brain necrosis or other serious complications, unless the volume of normal tissue exposed to retreatment is very small. The radiation dose that is required for good tumor control is close to the tolerance of normal brain tissue, and normal cells repair radiation injury to some extent, but never completely. Toxicity of radiotherapy may be acute or late. Expected acute toxicities of modern radiotherapy include fatigue, which generally resolves within 1 or several months after treatment, and hair loss in the treatment portals, with normal hair regrowth 3 to 6 months after treatment unless a higher dose to the scalp was necessitated by tumor invasion of bone close to the skin surface, in which case alopecia may be permanent. Some patients develop headache or slight nausea during radiotherapy, which generally responds to pain or antiemetic medications or to a course Of steroids.

Serious complications of radiotherapy tend to be from late toxicity and may be permanent. The risk of serious late toxicity ranges from 0 to 20%, with a patient-weighted average of 3.5%. Depending on the tumor location, patients may be at low risk of developing partial vision loss or blindness, hormonal deficits, cerebrovascular accidents or other cranial neuropathies, cataract, brain necrosis, or neurocognitive decline. In some papers, the authors linked complications to cases of reirradiation or doses clearly exceeding known tolerance levels currently employed [348; 350; 352]. Another potential serious complication of radiotherapy is the risk of induction of a second tumor or malignancy or of tumor

transformation to a more malignant histology. These risks are quite small; none of the papers reported a case of second malignancy attributable to radiotherapy or of an excessive risk of tumor transformation among patients treated with radiotherapy.

Radiotherapy was indicated in one patient in our series, he died before completion.

XII- Chemotherapy :

The role of adjuvant chemotherapy in patients with meningiomas remains unclear and continues to evolve. Chemotherapy has been applied mainly to inoperable lesions, especially in the setting of tumor progression or recurrence after some form of radiotherapy. Numerous approaches have been taken, including the use of traditional cytotoxic drugs, molecular agents, immunomodulators, and hormone-manipulating drugs.

A. Biochemotherapy:

Multidrug chemotherapy trials for recurrent meningiomas, whether aggressive, malignant, or refractory to surgery and radiotherapy, are scant [353; 180]. The best documented chemotherapy regimen (cyclophosphamide (500 mg/m²/ day for 3 days), , adriamycin (15 mg/m²/day for 3 days), and vincristine (1.4 mg/m² for 1 day).) has been used primarily in an adjuvant setting for the treatment of malignant meningiomas; however, without a control group, the results are difficult to interpret [354]. Other published regimens do not report response rates, length of response, or toxicity data and therefore should be regarded as investigational [353; 180; 354].

Modest success has also been reported with interferon α -2B (4 mU/m²/day, 5 days/week) in a small study of patients with unresectable and malignant meningiomas. Recombinant interferon- α (IFN- α) has been found to inhibit the growth of cultured human meningioma cell lines in vitro .

On the other hand, Several recent studies suggest that hydroxyurea(1000 to 1500 mg/day;20 mg/kg/day) has modest activity; responses are uncommon but some patients appear to have disease stabilization [355; 356].

Thus, hydroxyurea remains one of the most promising agents; however, further studies are necessary to fully characterize the effectiveness of this drug.

B. Targeted Therapy: [357; 354]

In contrast to the increasing understanding of the molecular pathogenesis and biology of systemic malignancies, including gliomas, relatively little is known about the molecular pathogenesis of meningiomas and the critical molecular changes promoting meningioma growth. Overexpression of several growth factors, including platelet-derived growth factor (PDGF), epidermal growth factor (EGF), and vascular endothelial growth factor (VEGF) and their receptors, and signal transduction pathways, such as the Ras/mitogen-activated protein kinase (MAPK), phosphatidylinositol-3-kinase (PI3K)-Akt, and phospholipase C (PLC)-g1-protein kinase C (PKC) pathways, have been implicated, but their relative significance is largely unknown. As a result, the most important molecular targets for meningioma-targeted therapy remain unknown.

PDGF: Accumulating evidence suggests that PDGF plays an important role in meningioma growth. The majority of meningiomas of all histological grades express PDGF ligands AA and BB and the PDGF-b (PDGF-b) receptor. Expression levels appear higher in atypical and malignant meningiomas than in benign meningiomas.

Laboratory data suggest that an autocrine PDGF loop supports meningioma cell growth and maintenance. These data suggested a sound rationale for testing PDGF inhibitors in meningioma patients. Imatinib is a potent inhibitor of the Bcl-Abl, PDGF-a and b receptors, and c-Kit tyrosine kinases. Its ability to inhibit PDGF receptors (PDGFr) with an IC50 of 0.1 mM suggested that it may have therapeutic potential in meningiomas.

The **EGF receptor** (EGFr) is overexpressed in more than 60% of meningiomas. EGF and transforming growth factor-a (TGF-a) activate these receptors and stimulate meningioma growth in vitro. Increased TGF-a immunoreactivity in meningiomas has been associated with aggressive growth. Currently, several anti-EGFr monoclonal antibodies are undergoing evaluation for other malignancies, including cetuximab, panitumumab, EMD 72000, nimotuzumab, and mAb 806. Trials of these agents in meningiomas likely will emerge and be

combined with correlative studies examining whether the antibodies can achieve therapeutic concentrations in vivo and inhibit meningioma EGFr activity in vivo.

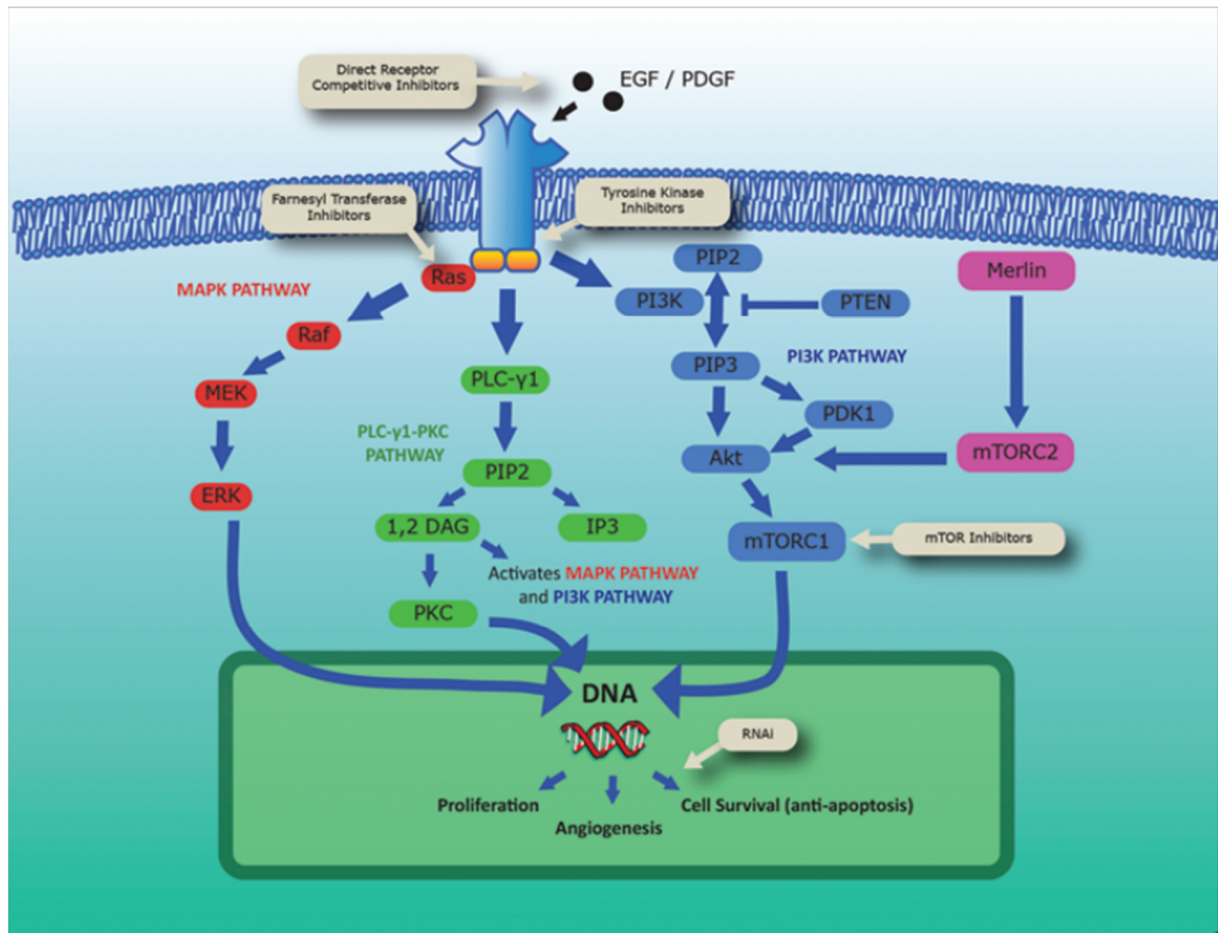


FIGURE 49 SIMPLIFIED SCHEME OF CELL SIGNALING PATHWAYS INVOLVED IN MENINGIOMA PATHOGENESIS. [178]

Among brain tumors, meningiomas show the highest frequency of **somatostatin receptor** expression. The largest study, comprising 52 patients with intracranial meningiomas studied by somatostatin scintigraphy, indicated a 90% positive rate of detection. In another study by the same group, postoperative somatostatin scintigraphy, was complementary to cranial MRI and in many instances (> 50%) of cases suggested residual tumor not evident by MRI. New somatostatin analogues with higher affinity may offer a novel, relatively nontoxic alternative treatment for patients with recurrent meningiomas. SOM230C(pasireotide) (60 mg intramuscular once every 4 weeks) is a novel, intramuscularly administered, long acting

somatostatin analogue with a wider somatostatin receptor spectrum (including subtypes 1, 2, 3, and 5) and higher affinity (particularly for subtypes 1, 3, and 5) than the sustained-release somatostatin.

VEGF and VEGFr are expressed in meningiomas, and the level of expression increases with tumor grade [180]. VEGF expression is increased twofold in atypical meningiomas, and 10-fold in malignant meningiomas compared with benign meningiomas. VEGF also plays an important role in the formation of peritumoral edema, inhibitors of VEGF and VEGFr are promising agents in meningiomas, with the potential not only to inhibit angiogenesis but also to decrease peritumoral edema. Studies evaluating inhibitors of angiogenesis as sunitinib, a multifunctional tyrosine kinase inhibitor with anti-VEGFr and PDGFr activity, PTK787 (vatalanib), another multifunctional tyrosine kinase inhibitor with anti-VEGFr activity have shown a partial radiographic response or stable disease. Lastly, Another trial just opening will study recurrent meningioma of all grades treated with single-agent bevacizumab (Avastin, Genentech), a VEGF ligand monoclonal antibody, in a prospective phase.

C. Hormonotherapy: [180; 178]

Both epidemiological (female predominance) and biochemical evidence (70% of meningiomas are progesterone receptor positive and 10 to 30% are estrogen receptor positive) suggest meningioma growth may be hormone dependent. Additionally, ~60% of meningiomas show staining of prolactin receptors. As a consequence, a variety of hormonal therapies have been utilized in the treatment of recurrent benign meningiomas not amenable to further surgery or radiotherapy.

Progesterone receptor inhibition initially appeared promising, as several small studies showed some efficacy of anti-progestational drug mifepristone. Overall, the long-term administration of mifepristone appears to be clinically well tolerated, with modest effect on tumor control, better in subgroup of male and premenopausal female patients. Mifepristone's lack of efficacy may be explained in part by the loss of progesterone receptor expression in meningiomas with increased proliferation index and histologic grade. This is relevant because these advanced tumors are the type most likely to be enrolled into clinical studies

A summary of Receptors Identified in Meningiomas:

Progesterone

Androgen

Glucocorticoid

Growth hormone

Somatostatin

Epidermal-derived growth factor

Insulin-like growth factors 1 and 2

Transforming growth factor- β

Interferon- α

Fibroblast growth factor-1

Estrogen

Prolactin

Conclusion:

The end point for any treatment must be long-term efficacy and safety in the management of benign meningiomas. Each case should be carefully evaluated with respect to risk, outcome, and morbidity/ mortality, regardless of the mode of management used.

SUMMARY

Summary:

Title: anterior and middle skull base meningiomas.

Author: Harati OumKaltoum.

Key words: Skull base meningiomas, anterior middle cranial fossa, classification, surgery, prognosis.

The aim of our study is to analyze the epidemiological, clinical, neuroradiological aspects, surgical management, and prognosis of anterior and middle skull base meningiomas of a series of 100 patients who underwent surgery at department the –Hôpital des Spécialités-Rabat- over a period of 13 years (2003-2016). They account for 17.4 % of intracranial meningiomas.

The mean age is 47 years. The most affected age group is between 40 and 49 with a female predominance of 70%. The mean diagnosis delay is 17months. Clinical presentation varies according to the site of meningioma, the most revealing symptoms were: decreased vision in 83%, Headaches in 81%. Neurological deficit was found in 16%, personality and memory disorder in 27%.

Neuroradiological assessment reveals calcifications in 32%, perilesional edema in 59% and bone reaction in 29%. The distribution of meningiomas by location is: Anterior fossa in 16%, suprasellar in 42%, laterosellar in 5%, lesser sphenoid wing in 19%, greater sphenoid wing in 10% and en plaque in 8%. The mean size is 3.61cm. Surgical removal was total (grade I and II) in 65cases, malignancy was found in 1%. Radiosurgery was indicated in 26 cases.

The rate of morbidity is 40 % , while the postoperative mortality is 12%. The 4 poor prognostic factors are: karnofsky scale<70, Tumor size>4.5cm , important perilesional edema and malignancy. (P<0.05)

40 patients had a long term follow up. 17.5% of cases had karnofsky scale<70, and 31% had a recurrence.

These results look promising despite the location of the tumor in the skull base which remains challenging regardless of the evolution of microsurgery techniques and radiosurgery.

Résumé

Titre : les méningiomes de l'étage antérieur et moyen de la base du crâne.

Auteur : Harati OumKaltoum.

Mots clé : base du crâne, étage antérieur et moyen, classification, chirurgie, pronostique.

Notre travail consiste à étudier le profil épidémiologique, Clinique, radiologique, thérapeutique, et pronostique des méningiomes de l'étage antérieur et moyen de la base du crâne, depuis une série de 100 patients au service de neurochirurgie de l'hôpital des spécialités de Rabat durant une période de 13ans (2003-2016). Ces tumeurs représentent 17.4% de l'ensemble des méningiomes intracrâniens admises au service.

La moyenne d'âge de nos patients est 47ans avec une prédominance féminine (70%) et un pic de fréquence de méningiomes entre 40 et 49 ans. Le délai moyen de diagnostic est de 17mois.

Le tableau clinique varie en fonction de la topographie du méningiomes. Il est dominé par une diminution de la vision dans 83%,des céphalées dans 81%, le déficit neurologique a été retrouvé chez 16%, l'atteinte de personnalité et de mémoire chez 27%.

Le bilan neuroradiologique objective des calcifications dans 32%, une réaction osseuse dans 29%, un œdème perilésionnel dans 59% .Il s'agit de méningiomes de l'étage antérieur dans 16%, méningiomes suprasellaire dans 42% , laterosellaires dans 5%, de la petite aile du sphénoïde dans 19%, de la grande aile du sphénoïde dans 10%, méningiomes en plaque dans 8%. La taille moyenne est 3.61cm.

L'exérèse a été macroscopiquement complète dans 64 cas. la malignité dans 1% à l'examen anatomopathologique. la radiochirurgie était indiqué chez 26 patients.

La morbidité dans notre série est de 40%, la mortalité postopératoire est 12%. Les quatre facteurs de mauvais pronostique sont : un karnovsky préopératoire <70%,une taille tumorale>4.5cm, un œdème perilésionnel important, et la malignité. (P<0.05)

A long terme, 40 patients ont eu un suivi, 17.5% avaient un karnovsky<70 avec un taux de récidence de 31%.

Les résultats restent très encourageants malgré la localisation au niveau de la base qui reste difficile en dépit de l'évolution des techniques microchirurgicales et de la radiochirurgie.

الملخص

العنوان: الأورام السحائية للرف الأمامي والمتوسط لقاعدة الجمجمة

المؤلفة: أم كلثوم حرتي

الكلمات الأساسية: قاعدة الجمجمة، الرف الأمامي والمتوسط، التصنيف، الجراحة، المآل.

يهدف عملنا إلى دراسة المظهر الباثي والسريري والإشعاعي والعلاجي. و عوامل المآل للأورام السحائية للرف الأمامي والمتوسط لقاعدة الجمجمة، من خلال سلسلة من 100 مريض بمصلحة جراحة الأعصاب بمستشفى الاختصاصات بالرباط، خلال مدة 13 سنة (2003-2016). تمثل هذه الأورام 17.4% من مجموع الأورام السحائية داخل الجمجمة التي تم إدخالها بالمصلحة.

بلغ متوسط أعمار المرضى 47 سنة مع هيمنة نسائية ب 70%، وذروة تردد الورم بين 40 و 49 سنة. بلغ متوسط آجال التشخيص 17 شهرا. اختلفت الاعراض حسب طبوغرافية الورم السحائي، فلقد هيمن ضعف البصر بنسبة 83%، والصداع ب 81%، ونقيصة عصبية ب 16%، واضطراب الشخصية والذاكرة ب 27%.

أظهر التقييم بالأشعة العصبية تكلسات ب 32%، وتفاعلا عظريا ب 61%، ووذمة محيطية بالآفة ب 59%. يتعلق الامر بورم سحائي للرف الامامي في 16%، وورم سحائي فوق سرجي في 42%، وجانب السرج في 5%، وورم في الجناح الأصغر للعظم الوتدي ب 19%، وفي الجناح الأكبر ب 10%، وورم سحائي لَوَّجِي ب 8%، كما بلغ طول الورم المتوسط 3.62 سنتمترا.

كان القطع كليا عيانيا في 64 حالة، وسجلنا حالة خبائة واحدة في التشريح المرضي. وقد تم اقتراح الجراحة الإشعاعية عند 26 مريضا.

بلغت المراضة في هذه السلسلة 40%، وبلغ معدل الوفيات التالي للعملية 12%. يمكن اعتبار العوامل الأربعة التالية عوامل المآل السيء: معدل كارنوفسكي قبل العملية أقل من 70، ثم تجاوز طول الورم 4.5 سنتمترا، ثم الوذمة المحيطة بالآفة مهمة، ثم الخبائة. على المستوى البعيد، توبع 40 مريضا كان معدل كارنوفسكي لديهم أقل من 70، مع معدل عودة المرض 31%

كانت النتائج مشجعة جدا نظرا للتموضع الصعب للورم رغم تطور الجراحة المجهرية الجراحة تقنيات الاشعاعية

INVESTIGATION LIST

I. Identity :

Name	Nb data
Gender	Age
Adress and phone Nb	Urbain rural

II. Past history :

Trauma
Radiation
Hormonal Fields
Others

III. Consultation delay

IV. Clinical presentation

Neuroradiological symptoms	ICP Neurological deficit Frontal syndrome Seizure Consciousness disorder Cranial nerve deficit Memory and personality disorder
Visual symptoms	Visual acuity Fundus Visual field
Endocrinological signs	

V. Physical examination

VI. Neuroradiological examination

A. Plain X rays

Normal
Bone reaction
Calcifications
others

B. CT scan

Location
size
Density
Calcifications
Perilesional edema
cyst
Bone reaction
Mass effect
others

C. MRI

Location
size
Intensity in T1 and T2
Calcifications
Perilesional edema
cyst
Bone reaction
Mass effect
Gado injection
Angio MRI

D. Angiography

vascularization			
Tumor injection			
blush			

E. Spectroscopy**VII. Biological examination**

Preoperative labs	CBC	ionogram	TP-TCK
Hormonal labs in suprasellar meningiomas	ACTH, cortisol, prolactinemia, LH, FSH, T3, T4, TSH, oestro, prog		

VIII. Treatment**A. Medical**

Anticonvulsant			
Corticotherapy			
others			

B. Surgical

Surgery date
approach
Macroscopical aspect
Insertion base
envahissement
Simpson grade
incidents

C. Radiosurgery

date
indication

Dose
volume
incident

IX. Pathology**X. Outcome****A. Short term :****1. ICU stay****2. Morbidity**

Perilesional edema
Hemorrhage
Neurological deficit
Rhinorrhea
infections
others

3. Death

Yes	cause	date
no		

B. Long term:**1. Karnofsky scale**

6 months
1 year
5 years
>5years

2. Recurrence:

Time of recurrence
Clinical signs
Radiological signs
management
outcome

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BIBLIOGRAPHY

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Serment d'Hippocrate

Au moment d'être admis à devenir membre de la profession médicale, je m'engage solennellement à consacrer ma vie au service de l'humanité.

- *Je traiterai mes maîtres avec le respect et la reconnaissance qui leur sont dus.*
- *Je pratiquerai ma profession avec conscience et dignité. La santé de mes malades sera mon premier but.*
- *Je ne trahirai pas les secrets qui me seront confiés.*
- *Je maintiendrai par tous les moyens en mon pouvoir l'honneur et les nobles traditions de la profession médicale.*
- *Les médecins seront mes frères.*
- *Aucune considération de religion, de nationalité, de race, aucune considération politique et sociale ne s'interposera entre mon devoir et mon patient.*
- *Je maintiendrai le respect de la vie humaine dès la conception.*
- *Même sous la menace, je n'userai pas de mes connaissances médicales d'une façon contraire aux lois de l'humanité.*
- *Je m'y engage librement et sur mon honneur.*

قسم أبقراط

بسم الله الرحمان الرحيم

أقسم بالله العظيم

في هذه اللحظة التي يتم فيها قبولي عضوا في المهنة الطبية أتعهد علانية:

1. بأن أكرس حياتي لخدمة الإنسانية.
2. وأن أحترم أساتذتي وأعترف لهم بالجميل الذي يستحقونه.
3. وأن أمارس مهنتي بوانزع من ضميري وشر في جاعلا صحة مريض هدي في الأول.
4. وأن لا أفشي الأسرار المعهودة إلي.
5. وأن أحافظ بكل ما لدي من وسائل على الشرف والتقاليد النبيلة لمهنة الطب.
6. وأن أعتبر سائر الأطباء إخوة لي.
7. وأن أقوم بواجبي نحو مرضاي بدون أي اعتبار ديني أو وطني أو عرقي أو سياسي أو اجتماعي.
8. وأن أحافظ بكل حزم على احترام الحياة الإنسانية منذ نشأتها.
9. وأن لا أستعمل معلوماتي الطبية بطرق يضر بحقوق الإنسان مهما لاقيت من تهديد.
10. بكل هذا أتعهد عن كامل اختيار ومقسما بالله.

والله على ما أقول شهيد .

جامعة محمد الخامس - الرباط
كلية الطب والصيدلة بالرباط

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تجربة مصلحة جراحة الدماغ والأعصاب بمستشفى الاختصاصات بالرباط
دراسة أتراب موحدة لـ 100 مريض على التوالي

أطروحة

قدمت ونوقشت علانية يوم : 28 شتنبر 2017

من طرف

السيدة: أم كلثوم حرتي

المزودة في: 21 شتنبر 1990 بالرباط

لنيل شهادة الدكتوراه في الطب

الكلمات الأساسية: قاعدة الجمجمة - الرف الأمامي والمتوسط - التصنيف - الجراحة - المأل.

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