ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Professor of Clinical Neurosurgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neuroanatomy and Neurophysiology

Editor
Seyed Ali Khonsary, MD
University of California at Los Angeles, Los Angeles, CA, USA

SNI
Open Access

Review Article

Combined presigmoid approach: A literature review

Sama S. Albairmani[1], Ahmed Muthana[2], Tabarek F. Mohammed[2], Mahmood F. Al-Zaidy[3], Oday Atallah[4], Ahmed Aljuboori[5], Zaid Aljuboori[6], Norberto Andaluz[7], Samer S. Hoz[7]

[1]Department of Neurosurgery, Al-Iraqia University, [2]Department of Neurosurgery, University of Baghdad, [3]Department of Neurosurgery, College of Medicine, University of Baghdad, Medical City, Baghdad, Iraq, [4]Department of Neurosurgery, Hannover Medical School, Hannover, Germany, [5]Department of Neurosurgery, Geisinger Clinic, [6]Department of Neurosurgery, Geisinger Commonwealth School of Medicine, Geisinger, [7]Department of Neurosurgery, University of Cincinnati Medical Center, Cincinnati, United States.

E-mail: Sama S. Albairmani - sama.sa909090@gmail.com; Ahmed Muthana - ahmed.m.najm@gmail.com; Tabarek F. Mohammed - tabarekmohammed12@gmail.com; Mahmood F. Al-Zaidy - mahmoodf.alzaidy@gmail.com; Oday Atallah - oday.atallah@yahoo.de; Ahmed Aljuboori - ahmedaljuboori9494@gmail.com; Zaid Aljuboori - zaljuboori1@geisinger.edu; Norberto Andaluz - andalun@ucmail.uc.edu; *Samer S. Hoz - hozsamer2055@gmail.com

***Corresponding author:**
Samer S. Hoz,
Department of Neurosurgery,
University of Cincinnati
Medical Center, Cincinnati,
United States.

hozsamer2055@gmail.com

Received: 18 July 2024
Accepted: 23 August 2024
Published: 20 September 2024

DOI
10.25259/SNI_594_2024

Quick Response Code:

Supplementary file:
https://dx.doi.org/10.25259/SNI_594_2024

ABSTRACT

Background: The presigmoid approach represents the standard route to reach the petrous area anterior to the sigmoid sinus. Several lateral skull base approaches have been integrated into this approach for the purpose of widening the window, leading to variable combined approaches and variable terminology. Herein, the authors conducted a systematic review of the literature to simplify understanding of the potential combination of different approaches and their complications.

Methods: PubMed, EMBASE and Web of Science databases were searched on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to include studies describing modifications of the presigmoid approach.

Results: We included 27 studies comprising 545 patients. Five combination types applied to the presigmoid approach were identified: Anterior petrosal (Kawase's) approach (Type-1), Supra-tentorial approach (Type-2), Infratemporal fossa approach (Type-3), retrosigmoid approach (Type-4), and Far-lateral suboccipital approach (Type-5). Type-1 combined approach was the commonest type (n = 204, 37.5%), followed by type-2 (n = 197, 36%), type-4 (n = 54, 9.9%), type-5 (n = 51, 9.4%), and type-3 (n = 39, 7.2%). Meningioma was the typical target lesion in all types except type 3, where it is solely used for paraganglioma. The petroclival region was the prevalent access location in all the types of combined presigmoid approaches (type-1, 92%; type-2, 95%; type-3, 100%; type-4, 59%; and type-5, 64%). The intraoperative lateral patient position was dominantly utilized in type-1, type-3, and type-5 approaches (65%, 100%, and 100%, respectively), while park-bench was the most common position in type-2 (36%) and type-4 (100%) approaches. Overall, all types exhibited good outcomes in the form of gross total resection of the lesion and the absence of surgical complications in the follow-up.

Conclusion: Presigmoid approaches are becoming increasingly complex with the application and integration of the lateral skull base approaches, resulting in broadening the surgical field and easy access to the targeted lesions. The importance of designing a comprehensive nomenclature of the combined presigmoid approaches may add distinctive contributions to the growing knowledge of neurosurgery.

Keywords: Far-lateral suboccipital approach, Kawase's approach, Presigmoid, Retro-sigmoid approach, Supra-tentorial craniotomy

INTRODUCTION

The term "Presigmoid approach" has been described since the early 80s of the last century in many different ways and used under several names such as "petrosal approaches" and "trans-tentorial approaches."[11] However, the terminology has become confusing with the evolution of new approaches, variations of techniques, and the lack of standard nomenclature. The presigmoid approach per se is a variation of approaches that can be divided between two main corridors, the translabyrinthine and retrolabyrinthine pathways, as we delineated in our previous paper.[16,29] However, when it comes to dealing with complex lesions, such as midline tumors with further extension toward adjacent critical areas, a combined approach might be needed as well. In this paper, we aimed to propose a set of potential combinations with the presigmoid approach, highlighting their surgical routes, main indications, and the possible complications related to each of them. We believe that having a unified terminology for the possible combined approaches would assist in choosing the right combined approach wisely according to the lesion characteristics, weighing all available options, and comparing their advantages.

METHODS

Literature search

A systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews.[23] The PubMed, EMBASE, and Web of Science databases were searched from inception to August 4, 2023, using the following search algorithm: (((presigmoid OR posterior petrosectomy OR posterior transpetrosal) AND ((combined trans-tentorial approach) OR (supra-infra-tentorium approach) OR (Anterior petrosal) OR (Kawase's approach) OR (combined petrosal approach) OR (total petrosectomy) OR (Retro-sigmoid approach) OR (combined pre-retro-sigmoid approach) OR (Far lateral suboccipital approach) OR (far lateral approach) OR (transcondylar approach) OR (Infratemporal fossa approach))). Studies were uploaded to Rayyan, and duplicates were erased.

Development of the combined presigmoid types

The presigmoid approach represents the standard route to reach the petrous area anterior to the sigmoid sinus. It provides a good scope for the lesion in the brainstem, petroclival region, jugular foramen, and internal auditory canal (IAC). Several modifications and combinations have been applied to this approach. In this study, the authors present the variants of possible lateral skull base approaches that can be used in combination with the presigmoid approach [Figure 1]. They include the Anterior Petrosal (Kawase's) Approach, also called (the combined petrosal approach or total petrosectomy). An anterior petrosectomy and a posterior retrolabyrinthine petrosectomy make it. Second, we have the Supra-tentorial craniotomy, also called combined trans-tentorial or supra-infra-tentorial approach. In this approach, a temporal-suboccipital craniotomy is required in addition to the mastoidectomy. Third, there is the infratemporal fossa approach (type A), which is a craniotemporal-cervical made by a mastoidectomy. Fourth, we have the retro-sigmoid approach, also called the combined pre-retro-sigmoid approach, which can be accessed by a mastoidectomy followed by a suboccipital craniotomy. Finally, there is the lateral suboccipital approach, also called the posterolateral or transcondylar approach. A posterolateral, retrocondylar suboccipital craniectomy, including the posterolateral rim of the foramen magnum, performs this combined approach.

The surgical steps and trajectories following the combined presigmoid approach vary considerably based on the target lesion, the clinical status of the patient, the related petrous and vascular anatomy, and the surgeon's experience. This variation is further, complicated by the high variability in the definition of each combination across the literature. A clear and simple description of possible variants of the

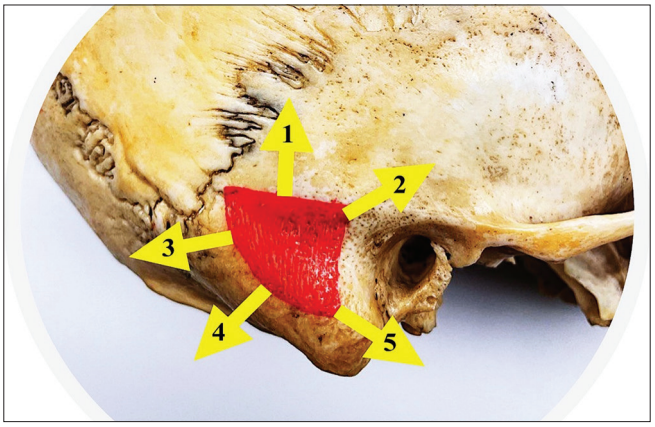

Figure 1: Examples of various combined approaches where the presigmoid approach is included superimposed on the right Norma-lateralis. The pre-sigmoid approach (red area) can be combined with the following: 1: Supra-tentorial craniotomy (combined trans-tentorial or supra-infra-tentorial approach). Target: petroclival lesion extends through tentorial hiatus. 2: Anterior petrosal (Kawase's) approach (combined petrosal approach or total petrosectomy). Target: complex petroclival lesion. 3: Retro-sigmoid approach (combined pre-retro-sigmoid approach). Target: large acoustic schwannoma with significant intra-meatal extension. 4: Far lateral suboccipital approach. Target: petroclival lesion with inferior extension to the foramen magnum. 5: Infratemporal fossa approach (type A). Target: Jugular foramen lesion with extra-cranial extension.

combined presigmoid approach, coupled with related access to the relevant anatomy, would provide significant assistance to the whole surgical team in improving communication and care delivery during lateral skull base surgery cases through the use of a clear, reproducible, and understandable nomenclature.

Study selection

Predefined inclusion and exclusion criteria were set. Published studies were included if they (1) reported the use of the presigmoid approach combined with additional surgical corridors proposed by our study, (2) presented available data on the surgical approach and target lesions as described by the authors, and (3) were written in English. Published studies were excluded if they were as follows: (1) literature reviews, case reports, conference abstracts, laboratory studies, or cadaveric studies; (2) lacking a clear description of the utilized surgical corridor; and (3) using the presigmoid corridor or the other combined approaches as a "stand-alone" approach.

Four independent reviewers (S.S.A., A.M., T.F.M., and O.A.) examined the titles and abstracts of all collected studies, which Dr. Hoz and Prof. Andaluz supervised. The authors then appraised the full text of articles that met the inclusion criteria. Any disagreements were resolved by discussion between the reviewers. The predetermined criteria included eligible articles, and references were searched to retrieve additional relevant studies. After the creation of the combined classification system, each approach reported in the included papers was classified based on that system.

Data extraction

Four independent authors (S.S.A., A.M., T.F.M., and O.A.) extracted data from the included articles, which Dr. Hoz and Prof. Andaluz confirmed. Missing data are not originally reported. Collected data comprised: authors, year of publication, sample size, age and gender, presentation symptoms and neurological deficits, type of lesion, location of lesion and relation to other structures, size of the lesion, compression of brain stem, the type of combined approach according to our classification, description of the approach, number of sessions, patient position, intraoperative neurophysiological monitoring, intraoperative complications, duration of surgery, postoperative neurological deficits, postoperative surgical complications, follow-up period, and outcome. The number of sessions described whether both approaches are performed in the same session or it is a staged operation. Outcomes were differentiated as: "good," for improved or resolved neurological deficits diagnosed at baseline; "fair," for unchanged neurological status compared to baseline; and "poor," for worse neurological status compared to baseline.

Data synthesis and quality assessment

The primary outcome of interest was the type of approach. The secondary outcomes of interest were the type, size, and location of the targeted lesions. For each study, the authors appraised the level of evidence in accordance with the 2011 Oxford Center for Evidence-Based Medicine guidelines and evaluated the risk of bias using the Joanna Briggs Institute checklist for case series.[15,21]

RESULTS

Study selection

Figure 2 illustrates our literature screening. The executed search strategies yielded a total of 529 citations (PubMed: 393; Embase: 86; Web of Science: 50). Following the preliminary evaluation of titles and abstracts in addition to subsequent full-text assessment, 27 case studies were finally included[1-10,12-14,19,20,22,24-28,30-35] [Table 1]. Quality assessment resulted in a low risk of bias for all included articles [Supplementary File 1].

The extracted major types

Five main approaches were found to form the major combinations to the presigmoid approach, which were

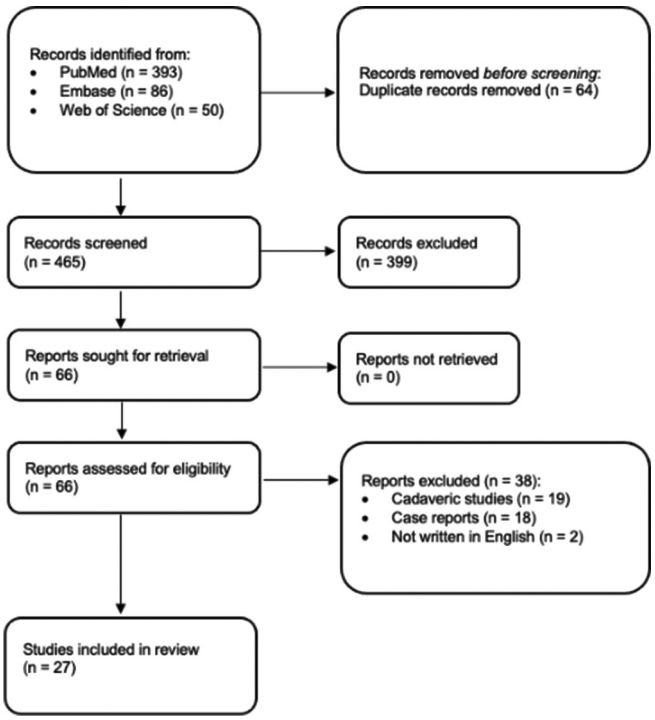

Figure 2: Flowchart of the study selection process.

Table 1: Overview of the included studies.

Author – year	Sample size	Age/Sex	Type of Approach	Type of Lesion (No.)	Location of Lesion (No.)	Patient position	Size of the lesion	Postoperative complications (No.)	Outcome (No.)
Hakuba – 1985	8	28/2 F, 6 M	Type 2	Craniopharyngioma (8)	Retrochiasmatic/ Suprasellar (8)	Park-bench position	>3 cm	No complications (8)	Good (4), Fair (1), Poor (2), Dead (1)
Hakuba – 1988	8	55.5/4 F, 4 M	Type 1	Meningioma (8)	Petroclival (8)	Park-bench position	-	No complications (5), CSF leak (1), Others (2)	Good (4), Fair (3), Dead (1)
Ammirati – 1992	5	48/3 F, 2 M	Type 2	Meningioma (5)	Petroclival (5)	-	-	No complications (5)	Good (4), Fair (1)
Bricolo – 1992	5	-	Type 2	Meningioma (5)	Petroclival (5)	Semisetting position	2–6 cm	No complications (5)	Good (4), Fair (1)
Gökalp – 1995	6	-	Type 4	Meningioma (6)	Tentorial (6)	Park-bench position	-	No complications (6)	-
Cho – 2002	7	42.6/6 F, 1 M	Type 1	Meningioma (7)	Petroclival (7)	Supine position	-	No complications (1), CSF leak (1), Others (5)	Good (4)
Seifert – 2003	52	-/32 F, 20 M	Type 2	Meningioma (22), Cystic Glioma (2), Epidermoid (3), Trigeminal Neuroma (3), Metastasis (2), Craniopharyngioma (1), Vertebrobasilar Aneurysms (15), Cavernoma (4)	Petroclival (52)	Semi-sitting position	-	No complications (31), CSF leak (17), Others (4)	Good (23), Fair (21), Poor (7), Dead (1)
Fujitsu – 2004	20	-	Type 4	Meningioma (20)	Petroclival (20)	Park-bench position	-	No complications (20)	Good (13), Fair (7)
Erkmen – 2005	34	50/-	Type 1	Meningioma (34)	Petroclival (34)	-	-	No complications (29), CSF leak (5)	-
Sanna – 2006	16	40/7 F, 9 M	Type 4	Jugular Schwannoma (16)	Jugular foramen (16)	-	1–4 cm	No complications (13) CSF leak (3)	Good (8), Fair (8)
Bambakidis – 2007	4	49.5/3 F, 1 M	Type 1	Meningioma (4)	Petroclival (4)	-	-	No complications (4)	-
Deveze – 2007	13	53.3/12 F, 1 M	Type 2	Meningioma (12)	Petroclival (12)	-	23.7 cm	No complications (7), CSF leak (6)	Good (11), Fair (1)
Jia – 2010	83	47.2/49 F, 34 M	Type 1	Meningioma (83)	Petroclival (83)	Lateral position	4.7 cm	No complications (83)	Good (83)
Watanabe – 2011	26	48/14 F, 12 M	Type 2	Meningioma (26)	Petroclival (26)	Lateral position	1–4.5 cm	No complications (24), Stroke (2)	Good (10), Fair (15), Dead (1)

(*Contd...*)

Table 1: (*Continued*).

Author – year	Sample size	Age/Sex	Type of Approach	Type of Lesion (No.)	Location of Lesion (No.)	Patient position	Size of the lesion	Postoperative complications (No.)	Outcome (No.)
Fric – 2011	12	54/6 F, 6 M	Type 4	Meningioma (6), Trigeminal neuroma (2), Acoustic neuroma (2), Clivus chordoma (1), Adenoid cystic carcinoma (1)	Petroclival (12)	Park-bench position	4.15 cm	No complications (4), CSF leak (6), Stroke (1), Others (1)	Good (2), Fair (6), Poor (2), Dead (1)
Matsui – 2012	41	54/31 F, 10 M	Type 5	Meningioma (41)	Petroclival (23), Tentorial (12), CVJ (6)	Lateral position	4.32 cm	No complications (39), CSF leak (2)	Good (29), Fair (10), Poor (1), Dead (1)
Eguchi – 2013	10	54.4/8 F, 2 M	Type 1	Meningioma (10)	Petroclival (7), Tentorial (2), Anterior petrosal (1)	Park-bench position	4.33 cm	No complications (9), CSF leak (1)	Good (7), Fair (3)
Xu – 2013	4	56.6/1 F, 3 M	Type 1	Meningioma (4)	Petroclival (4)	-	4.2 cm	No complications (4)	Good (2), Fair (2)
Sanna – 2013	39	47/-	Type 3	Paraganglioma (39)	Petroclival (39)	Lateral position	-	No complications (37), CSF leak (2)	Good (30), Fair (9)
Shibao – 2015	8	53.8/5 F, 3 M	Type 1	Meningioma (8)	Petroclival (8)	Lateral position	4.31 cm	No complications (8)	Good (6), Fair (2)
Tjahjadi – 2016	31	47.9/17 F, 16 M	Type 2	Vertebrobasilar Aneurysm (31)	Petroclival (31)	Park-bench position	0.98 cm	No complications (21), CSF leak (2), Stroke (8)	Good (16), Fair (6), Poor (6), Dead (5)
Sassun – 2016	31	55/-	Type 2	Meningioma (31)	Petroclival (31)	Supine position	-	No complications (31)	Good (25), Fair (5), Dead (1)
Morisako – 2021	23	54/19 F, 4 M	Type 1	Meningioma (23)	Petroclival (23)	Park-bench position	4.03 cm	No complications (23)	Good (13), Fair (9), Poor (1)
Haq – 2021	26	45.6/22 F, 4 M	Type 2	Meningioma (26)	Petroclival (26)	Park-bench position	4.52 cm	No complications (25), CSF leak (1)	Good (16), Fair (9), Poor (1)
Xie – 2022	10	48.3/8 F, 2 M	Type 5	Meningioma (10)	Petroclival (10)	Lateral position	3.1-7.2 cm	No complications (10)	Good (5), Fair (2), Poor (3)
Piper – 2023	10	57.8/6 F, 4 M	Type 1	Meningioma (10)	Petroclival (10)	-	3.7-6.0 cm	No complications (4), CSF leak (2), Stroke (4)	Fair (9), Dead (1)
Shibao – 2023	13	40.5/9 F, 4 M	Type 1	Trigeminal schwannoma (11), Extraventricular central neurocytoma (1), Metastatic tumor (1)	Posterior and Middle cranial fossa (13)	-	2.4 cm	No complications (12), CSF leak (1)	Good (6), Fair (7)

M: Male, F: Female, CVJ: Craniovertebral junction, CSF: Cerebrospinal fluid

categorized according to the target region and type of lesion:

Type 1 - Anterior petrosal (Kawase's) approach

This approach provides a wide surgical field for complex lesions in the skull base with proximity to critical neurovascular structures, including the cerebellopontine angle (CPA), ventral aspect of the brainstem, and the petroclival region, allowing for both supra-infra tentorial exposure with the possibility of hearing preservation.[4]

Type 2 - Supra-tentorial craniotomy

This approach is used for lesions that span the tentorium or extend through the tentorial hiatus and is perfect for central skull base lesions such as petroclival meningiomas and vascular lesions.[24]

Type 3 - Infratemporal fossa approach (type A)

This approach affords wide access to the lateral skull base from the temporal bone to the upper neck.

Type 4 - Retro-sigmoid approach

This approach improves visualization and accessibility of the CPA, particularly in large acoustic schwannoma with significant intra-meatal extension.

Type 5 - Far lateral suboccipital approach

This technique is especially useful for lesions involving the lower clivus, cervicomedullary junction, and foramen magnum.[5]

Participant demographics

A total of 545 patients were included [Table 2]. Age-based analysis showed a mean of 49.31 years old (range 6–75). Female gender accounted for the majority (64.07%, 264/412). At presentation, headache was the most common complained symptom (30.98%), followed by hearing symptoms (29.22%). Among all cranial nerves, vestibulocochlear nerve palsy was the most encountered one (27.74%), followed by trigeminal nerve palsy (20.89%).

Characteristics of the combined presigmoid approaches

Out of the total number of patients, the type-1 approach was the most common type used in the literature (n = 204, 37.5%), followed by type-2 (n = 197, 36%), type-4 (n = 54, 9.9%), type-5 (n = 51, 9.4%), and lastly type-3 in 39 cases (7.2%).

In terms of intraoperative patient position, a cohort of 446 cases were studied [Table 2]. Lateral position was used in

Table 2: Summary of the included studies.

Characteristics	Value (%)
General characteristics	
Cohort size (no.)	545
Demographics	
Age (years), mean (range)	49.31 (6–75)
Gender (female) (*n*=412)	264 (64.07)
Clinical presentation (*n*=510)	
Headache	158 (30.98)
Hearing symptoms	149 (29.22)
Visual symptoms	34 (6.67)
Motor symptoms	58 (11.37)
Sensory symptoms	57 (11.18)
Cerebellar symptoms	56 (10.98)
Cranial nerve palsy (*n*=292)	
CN-II	11 (3.77)
CN-III, IV, VI	14 (4.79)
CN-V	61 (20.89)
CN-VII	34 (11.64)
CN-VIII	81 (27.74)
CN-IX, X, XI, XII	91 (31.16)
Types of combined presigmoid approach (*n*=545)	
Type 1	204 (37.5)
Type 2	197 (36)
Type 3	39 (7.2)
Type 4	54 (9.9)
Type 5	51 (9.4)
Intra-operative patient position (*n*=446)	
Park-bench	144 (32.28)
Lateral	238 (53.36)
Supine	33 (8.09)
Semi-sitting	31 (7.6)
Types of lesions (*n*=545)	
Meningioma	402 (73.7)
Trigeminal neuroma	16 (2.94)
Acoustic neuroma	2 (0.37)
Craniopharyngioma	9 (1.65)
Paraganglioma	39 (7.17)
Jugular Schwannoma	16 (2.94)
Vertebrobasilar aneurysm	46 (8.46)
Cavernoma	4 (0.74)
Cystic glioma	2 (0.37)
Epidermoid tumor	3 (0.55)
Clivus chordoma	1 (0.18)
Adenoid cystic carcinoma	1 (0.18)
Extraventricular central neurocytoma	1 (0.18)
Metastatic tumor	3 (0.55)
Locations of lesions (*n*=545)	
Petroclival	481 (88.24)
Tentorial	20 (3.68)
Anterior petrosal	1 (0.18)
Posterior & middle cranial fossa	13 (2.39)
Retrochiasmatic/Suprasellar	8 (1.47)
Jugular foramen	16 (2.94)
Craniovertebral junction	6 (1.1)

(*Contd*...)

Table 2: (*Continued*).

Characteristics	Value (%)
Size of lesion (cm)	
Mean	3.8
Range	0.26–9.2
Postoperative complications (*n*=545)	
No complications	468 (85.87)
CSF leak	50 (9.17)
Stroke	15 (2.75)
Others	12 (2.2)
Tumor resection (*n*=351)	
Gross total resection	242 (68.94)
Subtotal total resection	81 (23.07)
Near total resection	12 (3.41)
Partial resection	16 (4.55)
Follow-up outcome (*n*=496)	
Good	325 (65.52)
Fair	135 (27.21)
Poor	23 (4.64)
Dead	13 (2.62)
Follow-up duration (in months)	
Mean	36.01
Range	1–288

most of the operations (53.36%, 238/446), followed by park-bench position (32.28%, 144/446). Further, an analysis of the intraoperative patient position in each type of the combined presigmoid approach is presented in [Table 3]. The most commonly used position for each type is stratified as follows: lateral in type-1, type-3, and type-5 (n = 91, n = 39, n = 51), park-bench in type-2, and type-4 (n = 65, n = 38). Supine and semi-sitting positions were used to a lower extent, with the former used in type-1 (n = 7), and type-2 (n = 26) and the latter used only in type-2 (n = 31).

Lesion characteristics

The analysis of the type and location of the treated lesions was conducted in our review [Table 2]. Out of the total included series, meningioma was harbored by most of the cases (n = 402, 73.7%). The majority of treated lesions were located in the petroclival region (n = 481, 88.24%). The mean size of the encountered lesions was 3.8 cm (range, 0.26–9.2 cm).

Lesion features were stratified by each type [Table 3]. Meningioma was the most commonly treated lesion in all types (type-1, n = 191; type-2, n = 128; type-4, n = 32; and type-5, n = 51) except type-3, in which the paraganglioma was the most and the only lesion treated using this approach (n = 39). Type-2 was used to treat a diversity of lesions other than meningioma, including vertebrobasilar aneurysm (n = 46), craniopharyngioma (n = 9), cavernoma (n = 4), epidermoid tumor (n = 3), and cystic glioma and metastatic tumors (both, n = 2). In terms of lesion location, the petroclival region dominated in all the types of combined presigmoid approaches (type-1, n = 188; type-2, n = 189; type-3, n = 39; type-4, n = 34; and type-5, n = 33). Tentorial region was able to be accessed using type-1 (n = 2), type-4 (n = 6), and type-5 (n = 12). Figure 3 shows the petroclival lesions accessed through the combined presigmoid approaches.

Tumor resection, postoperative complications, and follow-up outcome

For the extent of tumor resection, a cohort of 351 cases was analyzed [Table 2]. Remarkably, gross total resection (GTR) was achieved in the majority of cases (n = 242, 68.94%), followed by subtotal resection in 81 cases (23.07%). Stratified by each type: GTR was achieved in 35/64 of type-1 approach, 110/170 of type-2, 32/39 of type-3, 23/27 of type-4, and 42/51 of type-5.

In terms of postoperative complications, the majority of the included cases had no complications (n = 468, 85.87%). Temporary cerebrospinal fluid (CSF) leak was exhibited in 50 cases (9.17%), brainstem infarction in 15 subjects (2.75%), and other complications, including extradural hematoma, salivary fistula and vascular injury were encountered in 12 cases (2.2%). In our systematic review, we divided patient outcomes into four categories: good outcomes for patients with improved neurological deficits, fair outcomes for patients with residual or persistent deficits, poor outcomes with new disability, and fatal outcomes. The outcome metrics after the combined approaches in 501 subjects revealed good outcomes in the majority of cases (n = 328, 65.47%) and fair outcomes in 136 cases (27.15%). The mean follow-up duration was 36.01 months, ranging from 1 to 288 months.

Postoperative complications and outcomes were stratified by the types of combined presigmoid approach [Table 3]. Overall, all the types showed good outcomes and no complications in the majority of situations. However, among all the types, the type-2 approach was associated with a higher complication rate. Out of all the cases suffered from CSF leak and stroke, the majority of them were treated using the type-2 approach (CSF leak, n = 26/50; Stroke, n = 10/15). In addition, the majority of fair and poor outcomes cases underwent a type-2 approach. Finally, out of 13 dead cases, the type-2 approach was used in 9 of them.

DISCUSSION

In our systematic review, we found that five main lateral skull base approaches are being used independently in combination with the presigmoid approach, making the presigmoid approach a traffic point for the surrounding possible combinations [Figure 4]. Choosing the optimal approach for complex, extensive lesions occupying the petrous bone can be challenging. Such lesions represent those extending to the

Table 3: Summary of the types of combined presigmoid approach.

Characteristics	Type 1	Type 2	Type 3	Type 4	Type 5	Total
Sample size	204	197	39	54	51	545
Type of lesion	***n*=204**	***n*=197**	***n*=39**	***n*=54**	***n*=51**	***n*=545**
Meningioma	191	128	-	32	51	402
Trigeminal neuroma	11	3	-	2	-	16
Acoustic neuroma	-	-	-	2	-	2
Craniopharyngioma	-	9	-	-	-	9
Paraganglioma	-	-	39	-	-	39
Jugular Schwannoma	-	-	-	16	-	16
Vertebrobasilar aneurysm	-	46	-	-	-	46
Cavernoma	-	4	-	-	-	4
Cystic glioma	-	2	-	-	-	2
Epidermoid tumor	-	3	-	-	-	3
Clivus chordoma	-	-	-	1	-	1
Adenoid cystic carcinoma	-	-	-	1	-	1
Extraventricular central neurocytoma	1	-	-	-	-	1
Metastatic tumor	1	2	-	-	-	3
Location of lesion	***n*=204**	***n*=197**	***n*=39**	***n*=54**	***n*=51**	***n*=545**
Petroclival	188	189	39	32	33	481
Tentorial	2	-	-	6	12	20
Anterior petrosal	1	-	-	-	-	1
Posterior & middle cranial fossa	13	-	-	-	-	13
Retrochiasmatic/Suprasellar	-	8	-	-	-	8
Jugular foramen	-	-	-	16	-	16
Craniovertebral junction	-	-	-	-	6	6
Intra-operative patient position	***n*=139**	***n*=179**	***n*=39**	***n*=38**	***n*=51**	***n*=446**
Park-bench	41	65	-	38	-	144
Lateral	91	57	39	-	51	238
Supine	7	26	-	-	-	33
Semi-sitting	-	31	-	-	-	31
Tumor resection	***n*=64**	***n*=170**	***n*=39**	***n*=27**	***n*=51**	***n*=351**
Gross total resection	35	110	32	23	42	242
Sub-total resection	17	54	-	2	8	81
Near total resection	6	-	5	1	-	12
Partial resection	6	6	2	1	1	16
Postoperative complications	**1 *n*=204**	***n*=197**	***n*=39**	***n*=54**	***n*=51**	***n*=545**
No complications	182	157	37	43	49	468
CSF leak	11	26	2	9	2	50
Stroke	4	10	-	1	-	15
Others	7	4	-	1	-	12
Follow-up outcome	***n*=163**	***n*=196**	***n*=39**	***n*=47**	***n*=51**	***n*=496**
Good	125	113	30	23	34	328
Fair	35	58	9	21	12	136
Poor	1	16	-	2	4	24
Dead	2	9	-	1	1	13

CSF: Cerebrospinal fluid

midline and anterior territories of the brainstem, including the petroclival and retroclival regions and skull base foramina of the posterior cranial fossa, like the jugular foramen. The presigmoid approach per se has been extensively analyzed and recently classified in the literature.[16-18] It mainly targets the petrous temporal bone and is used either as a target

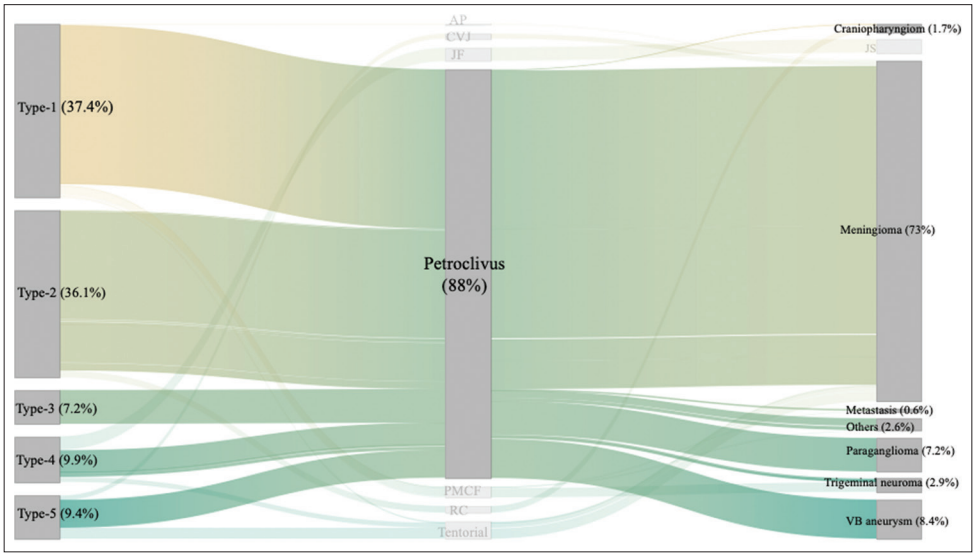

Figure 3: Graphic diagram showing the possible lesions located in the petroclival region that can be accessed through the five types of combined presigmoid approach. AP: Anterior petrosal, CVJ: Craniovertebral junction, JF: Jugular foramen, JS: Jugular schwannoma, PMCF: Posterior and middle cranial fossa, RC: Retrochiasmatic, VB: Vertebrobasilar.

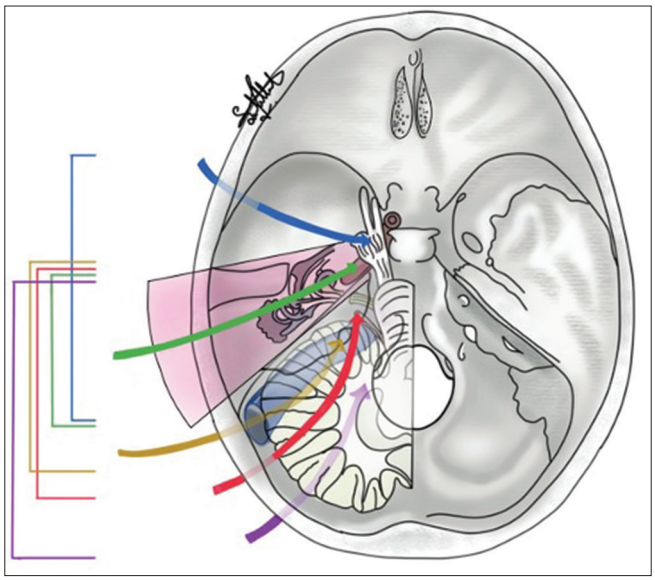

Figure 4: The proposed combination approaches use one of five lateral skull base approaches in addition to the presigmoid approach, which represents a traffic point (highlighted in pink). The Blue arrow is the Kawase approach, accessed by a temporobasal craniotomy, and represents an epidural approach. Green is a Supratentorial approach, accessed by temporo-occipital craniotomy, and represents a superior extension of the mastoidectomy done for the presigmoid. Yellow is the Infratemporal fossa (type A) approach, which is a craniotemporal-cervical approach that runs along the lowest aspect of the temporal bone to expose the area of the jugular foramen. Red is a Retrosigmoid approach, accessed by a lateral sub-occipital craniotomy. A purple is a Far-Lateral approach, which is also accessed by a lateral sub-occipital craniotomy with a possibility to include the posterior foramen magnum rim.

for intracanalicular lesions or as a route to access the IAC, jugular foramen, or the brainstem. The main advantage of using a combined approach lies in providing direct tumor visualization, minimum cerebellar retraction, and preserving the surrounding neurovascular structures. Using a combined presigmoid approach is preferable, in a lot of cases, to use a single invasive presigmoid approach. Our thorough scoping review revealed that the presigmoid approach is usually combined with another lateral skull base approach when the lesion meets any of the three criteria: (1) spans the tentorium, (2) extends to the middle cranial fossa, and (3) have a significant extension through one of the adjacent foramina.

Overall, the most extensive of the combinations is the combined-combined approach which represents a far lateral-combined supra and infratentorial. This approach might be used occasionally for petroclival lesions across the entire length of the posterior fossa, extending from above the petrous apex to beyond the foramen magnum.

Lesion types and locations

Our analysis revealed that the petroclival region was the most targeted location across all five types. It is accessed by more than 90% in Kawase's trans-tentorial and infratemporal fossa (type A) combined approaches (types 1, 2, and 3, respectively) as they reach the petrous bone through the middle cranial fossa. Interestingly, all of the lesions accessed by type 3 are located in the petroclival region. For lesions occupying the jugular foramen, the retrosigmoid and the far lateral suboccipital combined approaches (types 4 and 5, respectively) are used.

When it comes to lesion type, meningioma is the most common type of lesion that is targeted by all the combined presigmoid approaches, except for type 3, as mentioned previously. Meningiomas form 74% of all lesion types, with the majority being located in the petroclival region, representing 93%. Type 5 has been used exclusively for meningiomas; on the contrary, type 3 has targeted only paragangliomas occupying the petroclival region. However, the other combined presigmoid approaches have also been used for a minority of lesions occupying a variety of regions like the retrochiasmatic/suprasellar regions.

Intraoperative patient position

The lateral position and park bench positions were used in the majority of combined presigmoid approaches, and they targeted the petroclival region in over 80% of cases. The lateral position has been used in all the combined presigmoid approaches except for the retrosigmoid approach (type 4), which used the park bench position in all the cases. On the contrary, types 3 and 5 were noticed to use the lateral position in all their related cases. Other intraoperative positions included semi-sitting and supine positions, which were utilized to a lesser extent, forming only 14% of the total operations used for the combined presigmoid approaches.

Tumor resection outcome

Based on the resection level of lesions targeted by combined presigmoid approaches, GTR formed 68% of tumor resection outcomes, leaving 32% where GTR could not be achieved, and resection instead was done by either sub-total, near-total, or partial resection. The GTR percentage was the highest in types 3 and 5, making 82%, and lowest in the type 1 approach forming 54%. In Kawasi's approach (type 1), the lower percentage is likely due to the location of the lesions targeted in this approach, which include those of the skull base with proximity to critical neurovascular structures, including the CPA and ventral aspect of the brainstem.

Postoperative complications

The reported complication rate in our systematic review was 15%, including CSF leak forming 9% and being the most common complication in all the five combined approaches. It is followed by stroke at 3%, and other minor complications forming only 2% (Including seizure, venous congestion, coagulopathy, dry eyes, exposure keratitis, and pulmonary complications). Regarding the CSF leak, it was around 5% in types 1, 3, and 5 and was more prominent in types 2 and 4, forming 13% and 17% subsequently. Stroke, on the other hand, was around 2% in types 1 and 4 and 5% in type 2. From these findings, the type 3 approach seems to be the safest. However, this might be inaccurate given the small sample size included for this type of approach. As a consequence, the exact degree of safety may not be reliable enough to be determined and compared between the five combined approaches precisely. In general, good outcomes, on average, formed 65% in all five combined approaches, forming the highest rates in types 1, 2, and 3 (76–80%) and lower rates in types 4 and 5, 50% and 67%, respectively. Poor outcomes, on the other hand, ranged from 1-9%, being the highest in type 2 and lowest in type 1 combined presigmoid approach. Finally, the fatality rate was also recorded and was highest in type 2, forming 5% of cases, while the rest of the approaches were around 1%.

These combined approaches should have a unified terminology in the literature. Each of the five mentioned approaches can represent the main or the alternative pathway to target a specific lesion, and the choice among them can be determined preoperatively depending on the tumor's radiological features. However, without a unified and innovative nomenclature, combined approaches to the presigmoid approach will remain being used vaguely, sometimes determined by the surgeon intraoperatively and other times by adding the phrase "extended" to the original approach.

CONCLUSION

Presigmoid approaches are becoming increasingly complex with the application and integration of the lateral skull base approaches, resulting in broadening the surgical field and easy access to the targeted lesions. The importance of designing a comprehensive, simple, and precise nomenclature of the combined presigmoid approach may add distinctive contributions to the growing knowledge of neurosurgery.

Acknowledgments

We acknowledge Sama S. Albairmani for providing the graphical illustration [Figure 3].

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Ammirati M, Samii M. Presigmoid sinus approach to petroclival meningiomas. Skull Base Surg 1992;2:124-8.
2. Bambakidis NC, Kakarla UK, Kim LJ, Nakaji P, Porter RW, Daspit CP, *et al*. Evolution of surgical approaches in the treatment of petroclival meningiomas: A retrospective review. Neurosurgery 2008;62:1182-91.
3. Bricolo AP, Turazzi S, Talacchi A, Cristofori L. Microsurgical removal of petroclival meningiomas: A report of 33 patients. Neurosurgery 1992;31:813-28.
4. Cho CW, Al-Mefty O. Combined petrosal approach to petroclival meningiomas. Neurosurgery 2002;51:708-18.
5. Devèze A, Franco-Vidal V, Liguoro D, Guérin J, Darrouzet V. Transpetrosal approaches for meningiomas of the posterior aspect of the petrous bone: Results in 43 consecutive patients. Clin Neurol Neurosurg 2007;109:578-88.
6. Eguchi K, Tahara A, Yamaguchi S, Matsushige T, Mitsuhara T, *et al*. Feasibility and limitations of the retrosigmoid and presigmoid approaches combined with the anterior petrosal approach to meningiomas in the petroclival area. Neurosurg Q 2013;23:7-12.
7. Erkmen K, Pravdenkova S, Al-Mefty O. Surgical management of petroclival meningiomas: Factors determining the choice of approach. Neurosurg Focus 2005;19:E7.
8. Frič R, Eide PK. The presigmoid approach for removal of tumours causing ventral compression of the brainstem. Surgical results and postoperative quality of life. Br J Neurosurg 2011;25:86-93.
9. Fujitsu K, Kitsuta Y, Takemoto Y, Matsunaga S, Tateishi K. Combined pre-and retrosigmoid approach for petroclival meningiomas with the aid of a rotatable head frame: Peri-auricular three-quarter twist-rotation approach. Skull Base 2004;14:209-15.
10. Gökalp HZ, Arasil E, Erdogan A, Egemen N, Deda H, Cerçi A. Tentorial meningiomas: 46. Neurosurgery 1995;36:46-51.
11. Gross BA, Tavanaiepour D, Du R, Al-Mefty O, Dunn IF. Evolution of the posterior petrosal approach. Neurosurg Focus 2012;33:E7.
12. Hakuba A, Nishimura S, Inoue Y. Transpetrosal-transtentorial approach and its application in the therapy of retrochiasmatic craniopharyngiomas. Surg Neurol 1985;24:405-15.
13. Hakuba A, Nishimura S, Jang BJ. A combined retroauricular and preauricular transpetrosal-transtentorial approach to clivus meningiomas. Surg Neurol 1988;30:108-16.
14. Haq IB, Wahyuhadi J, Suryonurafif A, Arifianto MR, Susilo RI, Nagm A, *et al*. Modified transpetrosal–transtentorial approach for resection of large and giant petroclival meningioma: Technical nuance and surgical experiences. J Neurol Surg Part A Cent Eur Neurosurg 2022;83:578-87.
15. Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, *et al*. The Oxford 2011 levels of evidence; 2011. Available from: http://www.cebm.net/index.aspx?o=5653 [Last accessed on 2024 Jul 11].
16. Hoz SS, Palmisciano P, Albairmani SS, Kaye J, Muthana A, Johnson MD, *et al*. A proposed classification system for presigmoid approaches. J Neurol Surg Part B Skull Base 2023;84:1-344.
17. Hoz SS, Palmisciano P, Ismail M, Sharma M, Muthana A, Forbes J, *et al*. Anatomical study of the supratentorial extension for the retrolabyrinthine presigmoid approaches. World Neurosurg 2024;188:e120-7.
18. Hoz SS, Sharma M, Palmisciano P, Johnson MD, Ismail M, Muthana A, *et al*. Peritrigeminal safe entry zone access to anterolateral pons using the presigmoid retrolabyrinthine suprameatal approach: A cadaveric morphometric study. Oper Neurosurg 2023;25:e303-7.
19. Jia G, Wu Z, Zhang J, Zhang L, Xiao X, Tang J, *et al*. Two-bone flap craniotomy for the transpetrosal-presigmoid approach to avoid a bony defect in the periauricular area after surgery on petroclival lesions. Neurosurg Rev 2010;33:121-6.
20. Matsui T. Therapeutic strategy and long-term outcome of meningiomas located in the posterior cranial fossa. Neurol Med Chir 2012;52:704-13.
21. Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, *et al*. Systematic reviews of etiology and risk. In: Joanna Briggs Institute reviewer's manual. Adelaide, Australia: The Joanna Briggs Institute; 2017. p. 217-69.
22. Morisako H, Ohata H, Shinde B, Nagahama A, Watanabe Y, *et al*. Minimal anterior and posterior combined transpetrosal approach for large petroclival meningiomas. J Neurosurg 2021;135:1180-9.
23. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al*. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
24. Piper K, Peto I, Tay VQ, Tai A, Danner C, Boyev KP, *et al*. Optimizing workflow in combined petrosectomy approaches: Surgical technique and case series. World Neurosurg 2023;175:e428-33.
25. Sanna M, Bacciu A, Falcioni M, Taibah A. Surgical management of jugular foramen schwannomas with hearing and facial nerve function preservation: A series of 23 cases and review of the literature. Laryngoscope 2006;116:2191-204.
26. Sanna M, Shin SH, Piazza P, Pasanisi E, Vitullo F, Di Lella F, *et al*. Infratemporal fossa approach type a with transcondylar-transtubercular extension for Fisch type C_2 to C_4 tympanojugular paragangliomas. Head Neck 2014;36:1581-8.
27. Sassun TE, Ruggeri AG, Delfini R. True petroclival meningiomas: Proposal of classification and role of the combined supra-infratentorial presigmoid retrolabyrinthine approach. World Neurosurg 2016;96:111-23.
28. Seifert V, Raabe A, Zimmermann M. Conservative (labyrinth-preserving) transpetrosal approach to the clivus and petroclival region--indications, complications, results and lessons learned. Acta Neurochir 2003;145:631-42.
29. Shen T, Friedman RA, Brackmann DE, Slattery WH 3rd, Hitselberger WE, Schwartz MS, *et al*. The evolution of surgical approaches for posterior fossa meningiomas. Otol Neurotol

2004;25:394-7.
30. Shibao S, Borghei-Razavi H, Orii M, Yoshida K. Anterior transpetrosal approach combined with partial posterior petrosectomy for petroclival meningiomas with posterior extension. World Neurosurg 2015;84:574-9.
31. Shibao S, Yoshida K. Simplified anterior transpetrosal approach without superior petrosal sinus and tentorial incision for lesions centered in Meckel's cave. Acta Neurochir 2023;165:1833-9.
32. Tjahjadi M, Niemelä M, Kivelev J, Serrone J, Maekawa H, Jahromi BR, *et al*. Presigmoid approach to vertebrobasilar artery aneurysms: A series of 31 patients and review of the literature. World Neurosurg 2016;92:313-22.
33. Watanabe T, Katayama Y, Fukushima T, Kawamata T. Lateral supracerebellar transtentorial approach for petroclival meningiomas: Operative technique and outcome. J Neurosurg 2011;115:49-54.
34. Xie T, Wang Y, Zhang X, Shao N, Lu W, Yang Q, *et al*. Endoscopic far-lateral supracerebellar infratentorial approach for petroclival region meningioma: Surgical technique and clinical experience. Oper Neurosurg 2022;22:290-7.
35. Xu F, Karampelas I, Megerian CA, Selman WR, Bambakidis NC. Petroclival meningiomas: An update on surgical approaches, decision making, and treatment results. Neurosurg Focus 2013;35:E11.

How to cite this article: Albairmani SS, Muthana A, Mohammed TF, Al-Zaidy MF, Atallah O, Aljuboori A, *et al*. Combined presigmoid approach: A literature review. Surg Neurol Int. 2024;15:342. doi: 10.25259/SNI_594_2024