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Systematic Review and Meta-Analysis

Surgical Management of Skull Base and Spinal Chordomas: A Systematic Review and Meta-Analysis

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Abstract

Background: Chordomas are rare tumors originating from residual chordate tissues, predominantly affecting the base of the skull and the axial skeleton. Aim: This systematic review investigates the anatomical aspects and neurosurgical treatment modalities of skull base and spinal chordomas. Methods: We conducted a systematic literature review, adhering to PRISMA guidelines, by searching Databases including PubMed/Medline, Scopus, ScienceDirect, and EBSCO. Data was managed using Microsoft Excel and analysis was performed using SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). PROSPERO Registration Number; CRD420261322007. Results: In this study, we conducted a systematic review and meta-analysis, including a total of N=2,083 patients with clinical and neurological manifestations, as outlined between Table I and Table IV. The analysis results are summarized in Table 1. N=1,485, (71.5%) patients, N=636, Gross total resection (GTR), N=640, subtotal resection (STR), N=568, Radiotherapy, as detailed in Tables I and II and Figures 1, 2, and 3. Heterogeneity was assessed as follows: I^2 = [23%, 24%, 32%]. P = 0.21. Conclusion: The aggressive nature of chordomas necessitates personalized treatment strategies. Surgical approaches, particularly for elderly patients, proved promising in chordoma excision. Despite advancements, further research into disease management and etiopathogenesis is crucial for improved prevention, detection, and treatment strategies. Adjuvant therapies exhibited enhanced survival rates, highlighting their significance in prolonging patients› lives post-surgery.

Keywords
Adjuvant therapy, chordoma, skull base, spine, sacrococcygeal, surgery

How to Cite:
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INTRODUCTION

Rudolf Virchow, in 1846, was the first to document an anomaly in the dorsum of the sella turcica, loosely referring to it as "chordomas." However, the term "chordoma" was formally coined by German neuroanatomist Hubert von Luschka in 1856. Subsequently, in 1857, Virchow provided the first histological description of a chordoma in the clivus, employing the term 11 years after Luschka introduced it. He estimated the annual incidence of chordomas to be 0.08 per 100,000 individuals [1].

Chordomas predominantly affect the skull base, comprising the paired frontal and temporal bones and the occipital, ethmoid, and sphenoid bones, as well as the axial skeleton, including the vertebral and sacral regions. These tumors are considered rare malignancies, thought to arise from remnants of notochordal tissue. The axial skeleton, particularly the skull base, is the most commonly involved site [2]. Histologically, chordomas are characterized by lobulated masses separated by thick fibrous septa and the presence of physaliphorous cells within a myxoid stroma. Based on histological features, chordomas are classified into chondroid, dedifferentiated, and classic subtypes, with the chondroid variant typically associated with a more favorable prognosis than the classic form [3].

Historically, research has focused primarily on prognosis and treatment outcomes rather than histopathological variations between cranial base and sacrospinal chordomas. While chordomas primarily affect adults in their fifth or sixth decade of life, they are rare in pediatric populations, accounting for approximately 5% of cases [4]. Interestingly, studies have indicated that individuals with skull base chordomas tend to be younger compared to those with chordomas in other anatomical locations. Differences in histological features between skull base and non-skull base chordomas have been noted, including a greater presence of fibrous septa and extracellular mucoid matrix, reduced chondroid features, and increased proliferative potential in spinal chordomas. Furthermore, skull base chordomas often exhibit hemosiderin deposition indicative of phagocytosis [5].

The skull base consists of the anterior, middle, and posterior cranial fossae. The middle cranial fossa is further divided by the petro-occipital fissure into central and lateral components. The anatomical complexity of the skull base facilitates the growth of both primary and metastatic tumors, contributing to a broad spectrum of malignancies [6]. Surgical management of tumors in this region is difficult due to their proximity to critical brain structures, the brainstem, major arteries, and cranial nerves, as emphasized by Messerer et al. [7].

This study aims to identify and analyze postoperative clinical outcomes following total and subtotal gross resections, as well as the most common locations of chordomas at the base of the skull, spine, and sacrococcygeal region, including their clinical and neurological manifestations, to optimize therapeutic and surgical interventions for improved initial results.

MATERIAL AND METHODS

A systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to investigate the anatomical and neurosurgical characteristics of skull base chordomas (Fig. 1). Databases including PubMed/Medline, Scopus, EMBASE, ScienceDirect, and EBSCO were searched using specific keywords. Data analysis was performed using Microsoft Excel and SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). PROSPERO Registration Number; CRD420261322007. Articles published in English between 1985 and 2025 that met the inclusion criteria were selected for review.

The study population was defined using the PICO (Population, Intervention, Comparison, and Outcomes) framework. The inclusion criteria focused on patients aged 18 to 85 years diagnosed with chordomas of the skull base, mobile spine, or sacrococcygeal region.

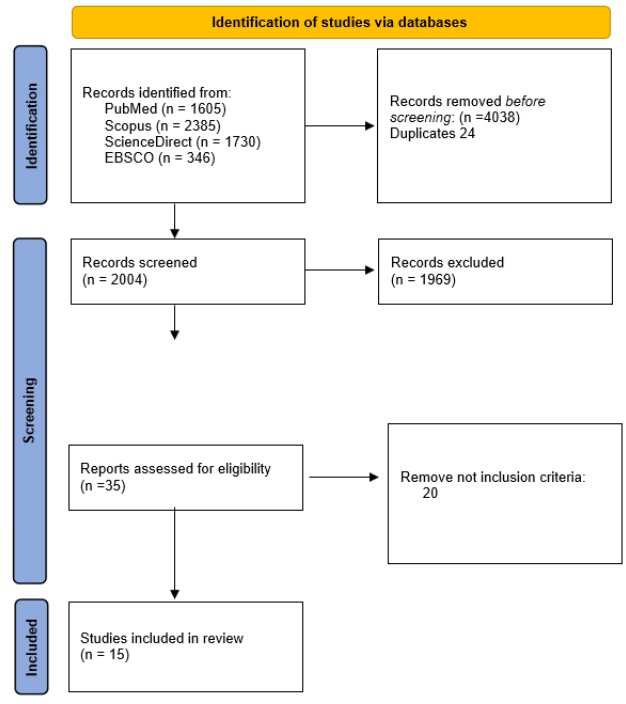


Figure 1: PRISMA on Skull base and Spinal chordomas flowchart

Search strategy and search terms

Four electronic databases, PubMed/MEDLINE, Scopus, ScienceDirect, and EBSCOhost were searched for articles published between January 1995 and December 2025. The search strategy combined controlled vocabulary (MeSH terms where applicable) and free-text keywords related to chordoma, surgical management, and anatomical location. In PubMed, the following search string was used: ("Chordoma"[MeSH] OR chordoma[tiab]) AND ("Surgery"[MeSH Subheading] OR surg*[tiab] OR resect*[tiab]) AND ("Skull Base"[MeSH] OR skull base[tiab] OR clivus[tiab] OR clival[tiab] OR spine[tiab] OR spinal[tiab] OR sacral[tiab] OR sacrum[tiab])*, limited to human studies. For Scopus, the search was performed using TITLE-ABS-KEY fields with the terms: chordoma, surg OR resect, and anatomical keywords (skull base, clivus, clival, spine, spinal, sacral, sacrum), restricted to original research articles and the specified publication years. Comparable keyword-based search strategies were applied in ScienceDirect and EBSCOhost using Boolean operators and anatomical site filters. The initial database search yielded 1,605 records from PubMed, 2,385 from Scopus, 1,730 from ScienceDirect, and 346 from EBSCOhost. All retrieved records were exported to reference-management software, and duplicates were removed prior to title- and abstract-level screening. The search strategy was developed in accordance with PRISMA guidelines to ensure methodological rigor and reproducibility. 1995 to 2024.

Inclusion Criteria

- Patients diagnosed with sacrococcygeal chordoma, spinal chordoma, or skull base chordoma.
- Age range of patients: 18 to 85 years or older.
- Studies reporting pre- and post-surgical interventions.
- Articles providing relevant results for the investigation.
- Selected articles focused on chordoma management; however, only five of these articles met the comprehensive inclusion criteria.

Exclusion Criteria

- Patients outside the specified age parameters.
- Cases where imaging and biopsy revealed tumors other than chordomas, despite presenting chordoma-like symptoms, as well as cases unrelated to chordoma pathology.
- Articles excluded based on factors such as case report quality, focus on non-surgical therapies, poor review quality, and irrelevance to the anatomical localization of chordomas.

Data Collection

The following standard search strategies were employed to collect data from the included studies on the frequency of chordomas. By Rayyan intelligent system, the Studies on skull base or spinal chordomas that met the inclusion criteria were selected, providing demographic information, intervention details, and control data. The focus was primarily on the most prevalent adult diagnoses of these chordomas. The review adhered to the published literature on population demographics, intervention and therapy details, prevention strategies, and study design.

Data Extraction and Analysis

Data extraction followed a structured approach, selecting manuscripts that met the inclusion criteria for research on the location, growth, pathology, and physiopathology of chordomas. This included demographic data, comparative studies, and designs from the published studies, with a specific focus on chordomas of the skull base, spine, and sacrococcygeal region, and their impact on spinal dynamics.

Risk of Bias assessment

Two reviewers assessed methodological quality separately. Articles were evaluated according to the Cochrane Group for Effective Health Practice and Organization (EPOC) risk of bias criteria (2017). (Rob2) The two reviewers assessed the generation of the allocation sequence, allocation concealment, and the similarity of baseline outcome measurements. Baseline characteristics were similar, and outcome data were incomplete, considering participant blinding, outcome assessor blinding, protection against contamination, selective reporting of outcomes, and other potential sources of bias in the studies. (Rob2). application developed by the Cochrane Collaboration. The selection, comparability, and neutrality were assessed across all domains, including high, low, and unclear criteria. Low-risk criteria were defined as access to relevant criteria, uncertain criteria, and inclusion criteria, as well as study selection and data collection criteria, where questions remained unanswered because they were not included in the comparison. High-risk criteria were defined as studies with high confounding and risk factors. All domains were applicable. A large-scale study examined the treatment of skull base chordomas, as well as spinal chordomas, using different approaches, from complete, partial, and subtotal macroscopic resections to distant lateral, suboccipital, occipital, and retrosigmoid approaches, as well as MISS-TLIF, TLIF, or PLIF spinal approaches, based on postoperative outcomes, and including radiosurgery and radiotherapy, with or without the use of a microscope. The risk of bias was assessed and the applicability of each study was examined to avoid uncertainties or other problems. We focused on the clinical and physiological characteristics, as well as the pathophysiology and symptoms affecting the cranial and spinal regions, before and after surgery.Meanwhile, validation and determination of compliance with the requirements were carried out through discussion or consultation with a third investigator (BE). According to Davey et al. (2013), reviewers classified the investigated studies as Low Risk if the criteria were rated as Low Risk; High, Some concerns if one or two criteria were also rated as High; and Some concerns and Low if more than two criteria were rated as Uncertain or High Risk.

Heterogeneity Assessment

Heterogeneity was assessed using the I^2 value reported in the forest plot created with RevMan 5.4.1.

Data Synthesis

Gross total resection (GTR) and subtotal resection (STR) data were compiled and presented as a bias risk diagram and a forest plot

Statistical Analysis

The summary statistics, including odds ratios (OR) and mean differences, were calculated for relevant events. Weighted mean differences and 95% confidence intervals (CIs) were used to characterize outcomes and specific data from the included studies. Statistical analysis was conducted using IBM Corp.'s Excel and SPSS Statistics for Windows, version 26.0 (published in 2020); R software and Excel, (Rob2), were employed for all main and subgroup analyses, with statistical significance set at a P-value of < 0.05 .

RESULTS

We conducted an intensive systematic review and meta-analysis, in which we identified N=6066 publications, of which N=2004 publications were screened, and, excluding abstracts, presentations, and congresses for eligibility, only N=35 were admitted, and, after removing some 20 studies that determined that they did not meet the inclusion criteria, we were only able to include N=15 studies. Including in this review a total of N=2,083 patients with clinical and neurological manifestations, as outlined between Table I and Table IV. N=1,485, (71.%) patients, 1,485 patients (71%) were diagnosed with chordomas table 1. N=636, GTR, (30%). N=640 (31%). STR, N=568, (27%). Radiotherapy, as detailed in Tables I and II and Figures 1, 2, and 3. Table II and Figure 4 specifically presented data on N=324 (15.%), chordomas of the skull base, N=17, (0.8%), extracranial extension chordomas, and N=186, (9%), sacral chordomas, along with N=42 cervical, (2%), 10 thoracic, (0.47%) and N=89 (4.2%), lumbar chordomas of the mobile spine. In total, N=484 (23%) surgical resections were reported. Table III and Figure 5 focused on N=241, (11.4%), chordomas and N=59, (2.8%), chordosarcomas. Table IV, along with Figures 6, 7, 8, and 9, included data on N=762, (36%), chordomas. Total (95% CI); 1.16 (0.45, 2.42). Heterogeneity: I^2 = 24%, Z = 1.25, P = 0.21. CI: 1.03 (0.97, 1.09). H.: I^2 = 29%, confidence interval test for overall effect: Z = 0.98, P = 0.33. CI: 0.03 (0.19, 0.21). H., I^2 = 32%, Z = 1.27, P = 0.20. According to an additional study with 47 patients who had initial surgery and 27 patients who had postoperative radiation, Tzortzidis et al. found that 71.6% of the patients in these cohorts had full resection. The location and size of the tumor, the surgeon's technique, clinical expertise, and the patient's preoperative clinical status all had an impact on surgical planning and the extent of resection margins. Over 95 patients with skull base chordomas received surgery in different research that ran from 1988 to 2011. During the first five years, the survival rates without recurrence were 74%, 6%, and 56%, respectively. According to a different study conducted between 2000 and 2011 with 39 patients, 71% of the patients had complete resection, which was in line with 71 patients' 75% five-year overall survival rate. [11, 12, 13]. The endoscopic endonasal excision of midline clival chordomas without substantial lateral extension has also been the subject of numerous research projects. Additionally, a comparison of 127 patients who had endoscopic resections and 639 patients who had open resections has been published. [14, 15, 22].

Table I. Recently studies of chordomas show by localization.

Authors	Sample size	year	Study design	Tumor location	GTR	STR	Radio-therapy	Outcomes / survival (OS)	Follow up	P= value
Cha et al. [3].	52	2019	Retrospective	Sacrococcygeal	20	21	12	5-10 years	6 months	0.05
Eid et al. [4].	30	2011	Comparative study	Skull base / sacrum	12	12	6	5-10 years	-	0.05
Ferrari et al. [5].	25	2010	Cases	Spheno-occipital-nasal	22	16	11	2 years	6 months-1 year	0.001
Chen G. et al. [56].	17	2021	Retrospective	clival	7	10	4	5 years	-	0.05
Fürtös AM. et al. [57].	13	2025	Systematic Review	Clivus	8	7	10	5-years	7 to 156 months	p = 0.002
Zhou et al. [30].	60	2019	Retrospective review	Clivus/sacrum	55	5	34	5-10 years	7.7 years	0.1
Zuckerman et al. [33].	50	2021	Retrospective cases series	Sacrum/mobile spine	41	20	13	5.3 years	N/A	0.02
Tamura T. et al. [36].	24	2015	Retrospective	Clival	22	9	20	5-10 years	10.2 years	0.05
Agner E. et al. [37]. .	630	2024	Comparative study	Skull base	163	369	354	5-10-20 years	10 years	0.001
Bai J. et al. [38].	167	2021	Retrospective	Dorsum Sellae/ Posterior Clinoid Process	7 3	66	11	—-	18.7 months	0.013

Glancz LJ et al. [39].	230	2024	Retrospective	Skull base/Cervical	23	17	21	4-year	32 months	0.002
Sallabanda M et al. [40]	24	2021	Retrospective	Skull base/spine	17	19	5	21-55 months	28 months.	0.06
Dastgheyb S. et al. [41].	42	2024	prospective cohort	Skull base/spine	54	-	30	83%	72 months	-
Wolf R. et al. [42].	57	2023	Retrospective	Skull base/spine	24	21	13	10 year	6.5 years	0.02
Chilukuri S. et al. [43].	64	2024	Retrospective	Skull base/spine	54	41	24	-	27.5 months	0.014

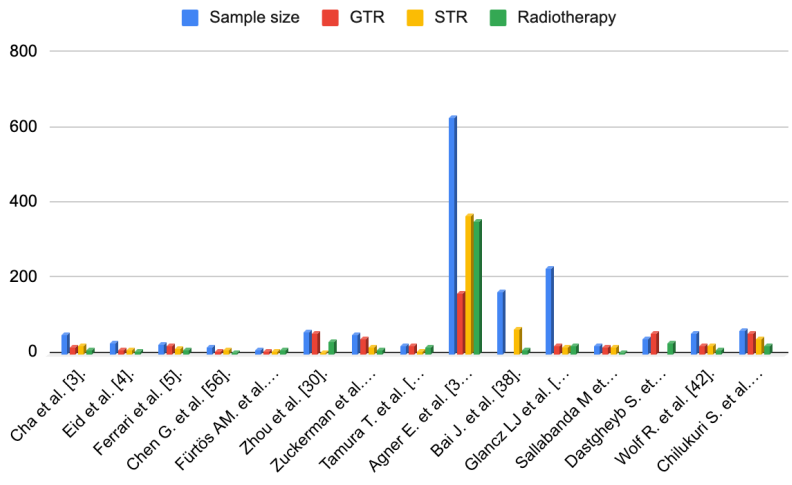


Figure 2 Graphics of the comparative studies of the Chordomas rate in small groups.

Table II. Most frequent locations of the cords: skull base, cervical, thoracic, lumbar, and sacral.

Reference	Skull base/ Clivus	extracranial extension	sacrococcygeal region /sacral/pelvis	Cervical	Thoracic	Lumbar	Surgical resection
[38].	27	17	16	3	1	0	44
[39].	24	0	31	0	0	5	55
[40].	26	0	10	3	0	6	49
[41].	15	0	5	16	9	12	5
[42].	30	0	20	14	0	5	41
[44].	85	0	0	6	0	0	91
[47].	8	0	3	0	0	5	16
[48].	11	0	25	0	0	6	28
[5].	1	0	11	0	0	13	22
[50].	97	0	65	0	0	37	133

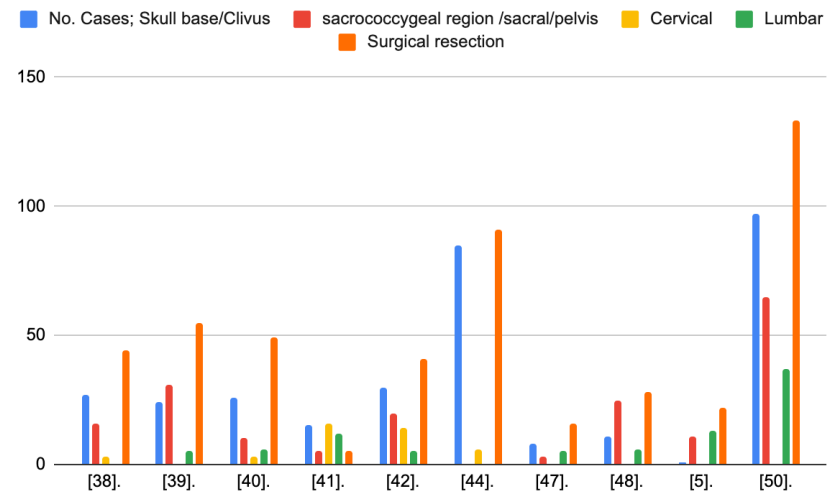


Figure 3. Most frequent location of chordomas in the regions of the spinal column.

Table III. Comparison of chordomas and their progression to chondrosarcomas treated with adjuvant therapy.

Reference	chordomas	chondrosarcomas	Proton beam therapy
[38].	49	18	70 Gy
[39].	19	5	60-74 Gy
[40]	42	12	79.2 Gy
[42].	54	10	70 Gy
[44].	77	14	70 GyE/35 fractions

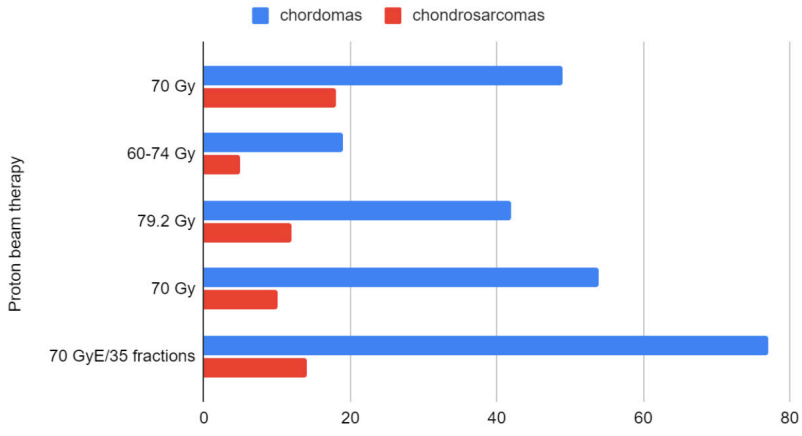


Figure 4. Comparing the frequency of therapies in chordomas vs. sarcomas with the use of proton beam therapy.

According to certain chordoma cases, 49% of procedures were carried out on patients with sacrococcygeal chordomas, whilst 17% of procedures were carried out on patients with cervical chordomas. High-grade sarcomas were categorized as potentially treatable by the World Health Organization (WHO), and palliative and survival care were mainly taken into consideration for recurrent cases. [16, 17, 18]. Interestingly, long-term survival was attained by more than two-thirds of individuals with these sarcomas. The major therapeutic option for both chordomas and chondrosarcomas is still complete surgical removal of the tumor. Surgery is the primary method used when neoadjuvant chemotherapy is not practical. Cisplatin, doxorubicin, and methotrexate are notable chemotherapeutic drugs utilized in chordoma therapy

[19, 20, 21]. The most popular excision techniques, according to a study analyzing the extension patterns of chordomas in 49 cases, were transethmoidal (36%), pterional (23%), and retrosigmoid (23%). The prevalence of neurological abnormalities affected the rate of surgical excision; those with neurological impairment had a greater rate (78%) than those without. These patients' survival rates varied from five to ten years. [22, 23, 24]. Despite its effectiveness, radical surgery was linked to a slight rise in morbidity [25]. According to a 1990–2005 retrospective analysis, the disease-specific survival rates for sacral chordomas ranged from 56% to 77%, with a pathology-free survival span of roughly 84 months. Approximately 71% of patients in this group developed metastases. Treatment approaches, such as cryosurgery and radiation therapy, were impacted by variables such as tumor recurrence, intralesional lesions, and large surgical margins [26]. Between 2003 and 2022, 42 individuals undergoing 85 surgical procedures for skull base chordomas were included in an analysis of clivus-region surgeries. The majority of lesions were found in the middle and upper clivus, and these procedures involved both open microsurgical and endoscopic endonasal techniques. Tumors were discovered by accident in 51% of the instances. After surgery, several individuals develop some urinary issues [27].

Table IV. present additional studies on chordomas by gross total resection and extend resection or partial resection or radiotherapy.

Authors	Sample size	Tumor Location	Surgical intervention	surgical field	Complementary Therapy	Follow up	P=value
Eid et al. 2011 [4]	30	Chordomas of the base of the skull	SRT	Extensive	Adjuvant radiotherapy/ radiosurgery (subtotal resection performed in 12 patients)	78 months,	<0.001
Cha et al. [3] 2019	52	Chordomas view of anatomical	Surgical	Extensive	Adjuvant radiotherapy / surgery	, 5-year life of expectancy	<0.002
Ferrarisi et al. 2010 [5]	25	Chordomas of the base of the skull	Surgical.	Extensive; intralesional	Adjuvant radiotherapy/ radiosurgery	5-year and 10-year survival of all patients	<0.001
Rich et al. 1985 [14]	48	Chordomas of the base of the skull	GTR	Extensive	adjuvant radiotherapy	1359 patients, Average life expectancy of 5-7 years	<0.005
Tzortzidis et al. [12] 2006	47	Chordoma of the skull base	GTR	Extensive	resection in 53 (71.6%) patients and subtotal resection was performed in 21 (28.4%) patients and	The average survival after 10 years is 31%.	<0.003
Bai J. et al. [38]. 2021	167	Chordoma of the skull base	GTR 31	Extensive resection 73, 66, 28	adjuvant radiotherapy	months 18.7	0.003
Guan X. et al. [45]. 2019	91	Skull base and spine	70 GyE/35	Extensive	photon-based RT	3 years	0.012
Shidoh S. et al. [46]. 2014	18	Skull base/ spine	GTR	extent of resection	-	-	-
Maioli M. et al. [47]. 2024	89	Spinal	Surgical/slides-	extent of resection	-	5-year	0.033
Aguiar Júnior S. et al. [49]. 2014	42	Skull base / spine	GTR	extent of resection	Adjuvant radiotherapy/ radiosurgery	28.5 months	0.25
Shakil H. et al. [51]. 2024	208	Skull base / spine	GTR	extent of resection	Adjuvant radiotherapy	5-, 10, and 15-year	0.036

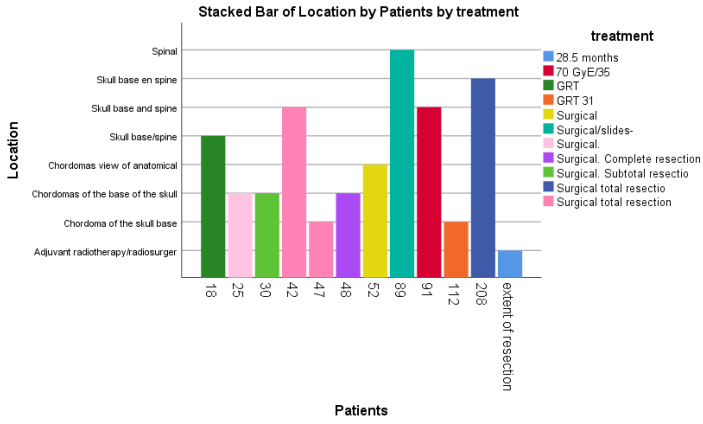


Figure 5. Surgical management of patients with chordomas in terms of location and therapeutic dose

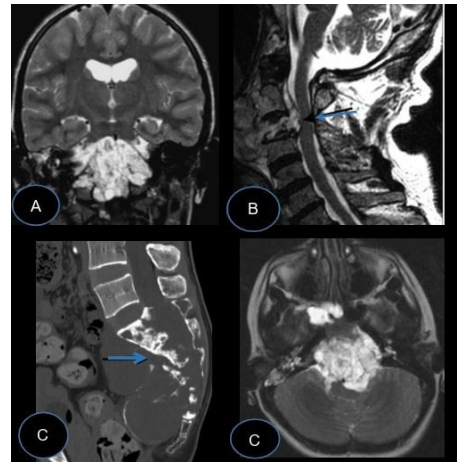
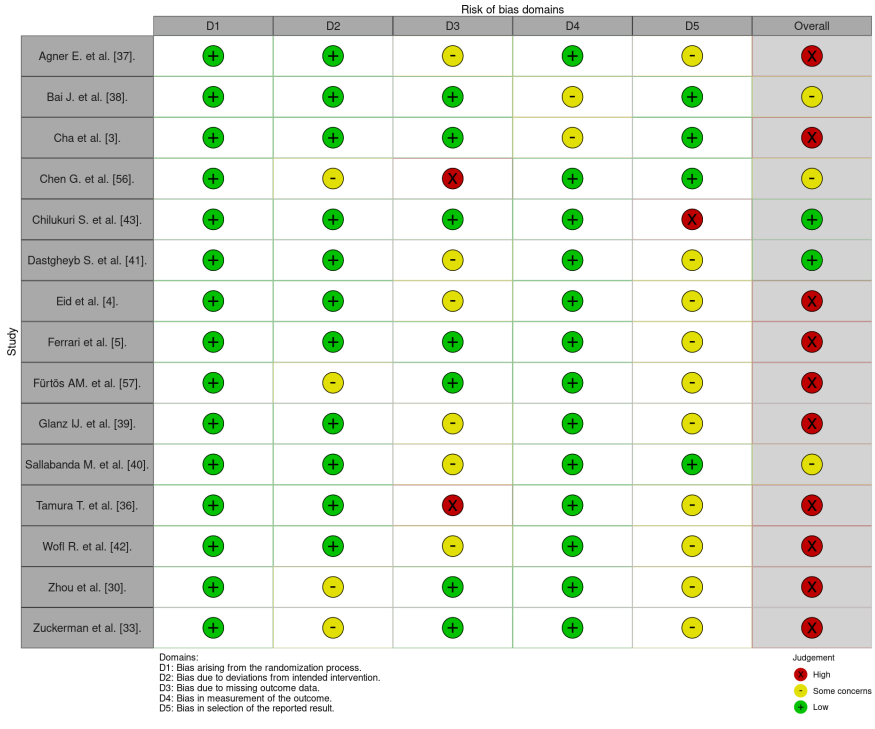


Figure 6: (a) Axial MRI demonstrating an intracranial chordoma; (b) A mass compressing the anterior epidural space (see blue arrow); (c) Sacral level lytic lesion with destruction and soft tissue mass with intramural calcifications; and (d) Coronal MRI displaying an intracranial chordoma-type mass.



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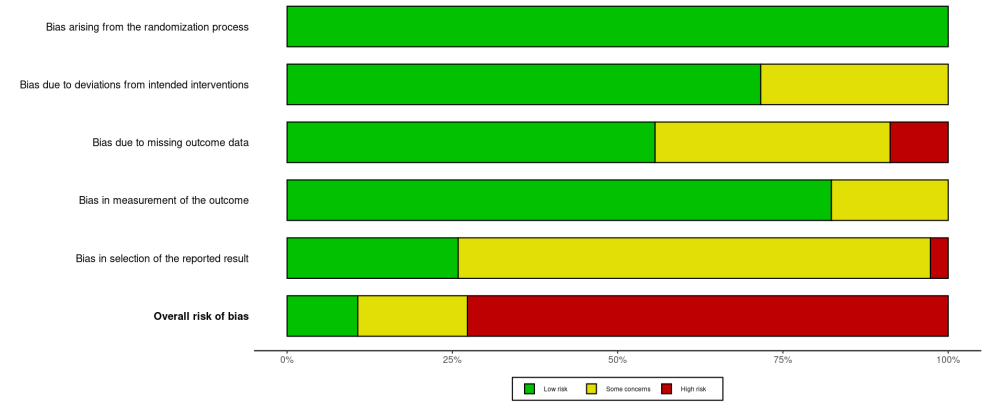

B

Figure 7. Quality assessment for meta-analysis according to the Rob2 tool: "traffic light" plots of the domain-level judgments for each individual study (Authors) (a, b), weighted bar plots of the distribution of risk-of-bias judgments within each bias domain research study. Risk of Bias Rob2., of Patients with Skull base and Spine Chordomas

DISCUSSION

Chordoma surgery is associated with significant morbidity and mortality, often necessitating the use of adjuvant therapies such as radiotherapy, including proton beam therapy [16]. While initial surgical interventions help reduce risks such as rebleeding, achieving complete tumor excision remains challenging due to the tumor's location, contributing to consistent 30-day mortality and reoperation rates across cases [9]. Several studies, such as the one by Robles et al. [10], highlight the importance of combining surgical approaches with adjuvant radiotherapy or radiosurgery. However, the choice of therapy is crucial, especially in cases where chordomas are located in deep and functionally vital regions of the brain, where treatment options remain controversial [11]. There are notable biological and physical differences between proton beam therapy and carbon ion radiation therapy when treating chordomas. Currently, intensity-modulated radiotherapy is the standard for chordoma treatment [23]. For spinal chordomas, a combination of imaging, surgical navigation, and spinal reconstruction techniques plays a pivotal role [24]. This combined approach of surgical resection and radiation therapy significantly enhances survival rates and impedes disease progression [28]. While open biopsies are not typically recommended, they may be necessary in certain cases. In such instances, CT-guided techniques using sharp needles are advised. For chordomas of the mobile spine and sacrum, therapy may be initiated during the final tumor excision [29].

Treatment variations have been noted, with male patients often receiving proton beam therapy for tumors located beyond the cervical region, while female patients tend to receive higher radiation doses [30]. Post-surgery, motor deficits vary, though some patients who underwent total sacrectomy at the S1 level retained or regained plantar flexion, allowing for ambulatory movement [31].

Optimal surgical outcomes require the block resection of sacral and mobile spine chordomas, contributing to better treatment results [32]. Molecular target therapies, such as Imatinib, have shown promise as effective treatments for chordoma, representing an emerging line of therapy [33].

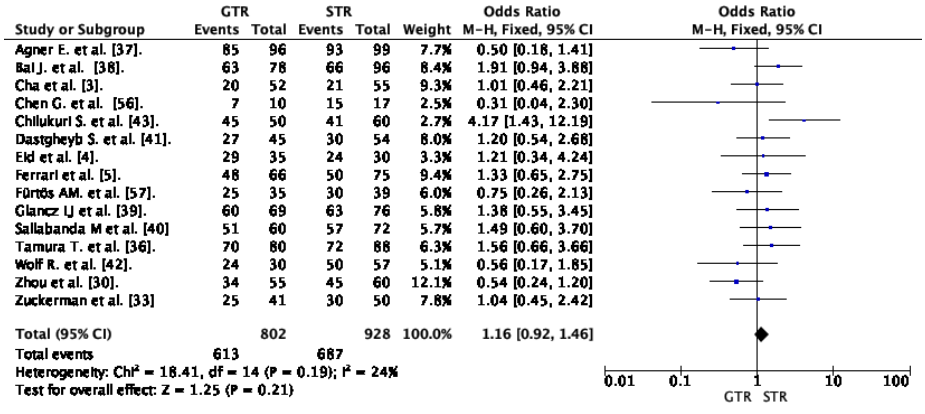

Figure 8. Forest plot; Odds-ratio Skull base and Spine Chordomas

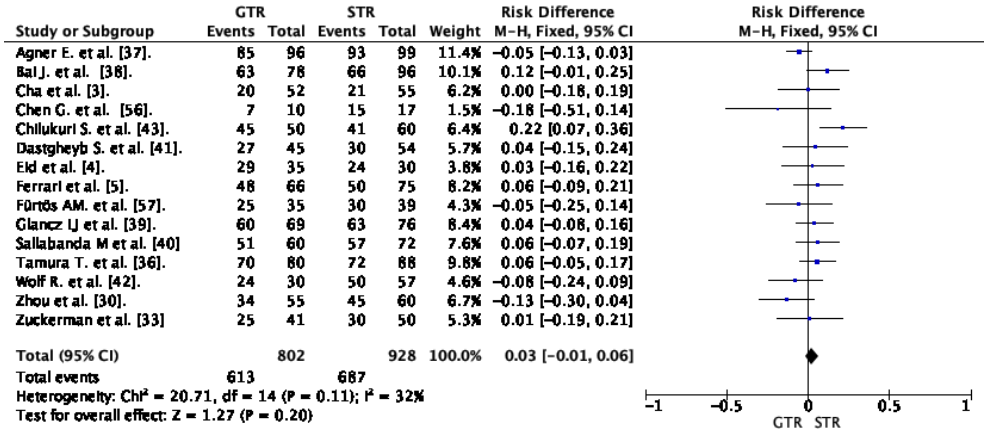

Figure 9. Forest plot; Risk-difference Skull base and spine chordomas of GTR vs. STR

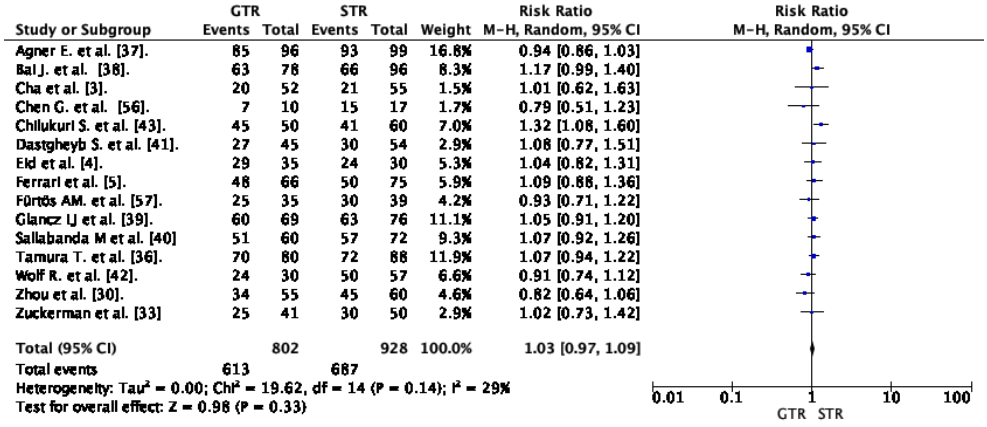

Figure 10. Forest plot; Risk-Ratio Skull base and Spine chordomas

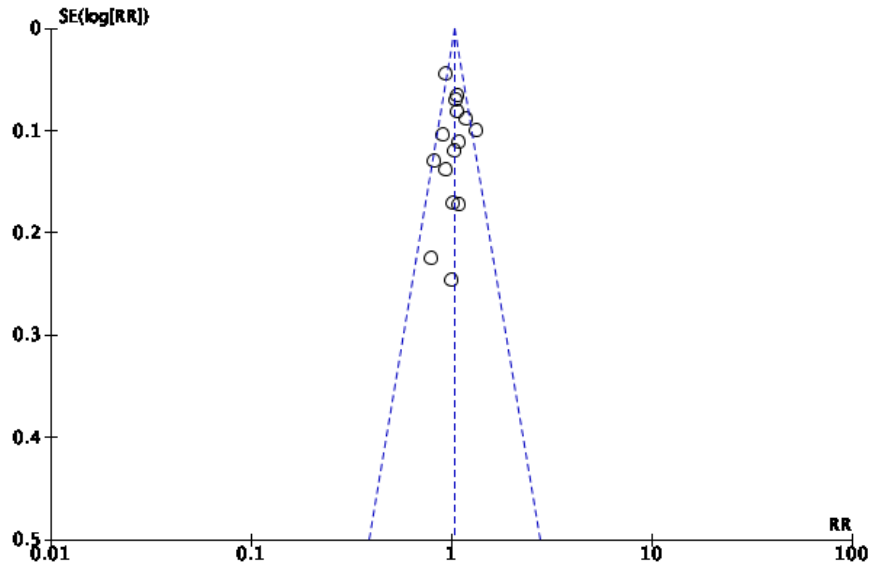

Figure 11. Funnel Plot of Chordomas of the Skull base and Spine

Clinical Presentation

The clinical symptoms of chordomas vary depending on their location and patients with chordomas of the skull base commonly present with headaches, cranial neuropathies, and endocrinopathies. In contrast, those with chordomas of the mobile spine and sacrum often experience localized pain, radiculopathies, or myelopathy, along with intestinal or bladder dysfunction. Due to their growth patterns, which are often painless, chordomas can become relatively large and are typically palpable depending on their location. [33, 34, 35]. Cervical spine chordomas can invade surrounding soft tissues, leading to dysphagia and airway obstruction. Sacral chordomas may extend into the presacral space, adjacent to the pelvis, and result in constipation, urinary retention, and visceral pain. [36, 37, 38]. Although most chordomas originate in the extradural space, there are also reports of intradural or intraparenchymal chordomas [39, 40, 41].

Sphenoid-occipital Chordomas

Chordomas of the cranial base are most commonly located in the clivus, presenting as an extensive midline soft tissue mass. On CT scans, these tumors are characterized by bone destruction and irregular intratumoral calcifications, indicating the invasive nature of the tumor. Post-contrast imaging can further reveal bone penetration and associated tissue damage [42, 43, 44].

Endoscopic Endonasal Approach

With this surgical technique, a 4 mm straight endoscope is used to remove the tumor first, and angled endoscopes are used for the best possible visualization. To guide the process, image navigation technology was used. The nasoseptal flap must be made for repair following the resection of the median concha. [45]. We chose the four-handed binosopharyngeal approach, which allowed for a bigger surgical space by resecting the posterior part of the nasal septum, because the tumor had spread into the subdural space. [47, 48, 46]. The Vidian canal was marked as a crucial reference point for the carotid arteries by puncturing the sphenoid sinus floor and clivus level. [49,50,51]. Subdural component removal, involving brainstem and basilar arteries, was then done carefully. Fascia was used as a subdural inlay for the multilayer reconstruction, coupled with oxidized cellulose and fibrin glue for the dural and bony margins, and a pedicled nasoseptal flap to cover the fascia. [52, 53]. During the reconstruction, pressure was applied for support using a 14+F Foley catheter [45, 54, 55].

Proteogenomic genetics of the Chordomas

Although extremely uncommon, skull base chordomas are aggressive bone tumors that occur frequently. Numerous research studies have examined their molecular properties, including phosphoproteomic, transcriptomic, proteomic, and genomic analyses that are integrative of 187 skull base chordoma cancers. It is necessary to consider chromosomal instability linked to the RPRD gene and chromosome 1q gain, which can serve as a target cell therapy in individuals who are unresponsive to traditional treatment. Immune subtyping can detect a subrefining associated with the loss of chromosomes 9p and 10q in immune evasion, since overexpression of mitochondrial functions can result in a worse outcome. Given the highly invasive nature of P-II tumors and the proteomic classification of P-II and P-III subtypes based on chromosomal instability and a cold immunity subtype, all of this was validated in 17 paired samples, which provided us with information on the biology of skull base chordoma and its management. [55].

LIMITATIONS AND FUTURE DIRECTIONS

The limitations of this study stem from the search parameters, which may have resulted in an overrepresentation of sacral or spinal chordomas, which generally have a better prognosis compared to skull base chordomas, particularly those in the clival region. The exclusion of pediatric studies further limited the scope, potentially omitting valuable information relevant to pediatric chordoma cases.

Skull base chordomas were included in an analysis of surgeries in the clival region. Most lesions were found in the middle and superior clivus, and these procedures involved open microsurgical and endoscopic endonasal techniques. The tumors were discovered incidentally in 51% of cases. After surgery, several patients developed urinary problems. While initial surgical interventions help reduce risks such as rebleeding, achieving complete tumor excision remains challenging due to the tumor's location, contributing to mortality rates.

CONCLUSION

This review demonstrates that good resection of GTR vs. STR chordomas, plus radiotherapy, can increase survival in patients with chordomas, both spinal and skull base. Heterogeneity was assessed, ranging from medium to low, which remains relevant in this study, according to statistics based on the forest plot. I^2: [23, 24, 32%]. $P < 0.19$.

1. The aggressive nature of chordomas necessitates personalized or combined treatment strategies for future benefits. Addressing severe side effects from skull base lesion removal, combined chemoradiotherapy, and conservative approaches is essential for optimizing patient care.
2. Generally patients may benefit from various surgical approaches for chordoma excision, including transsphenoidal, transbasal, cranioorbitozygomatic, transzygomatic dilated middle fossa, transcondylar, and transmaxillary techniques.
3. Despite significant advances in surgical techniques and targeted therapies, associated with further research is crucial to improve disease management. A deeper understanding of chordoma's etiopathogenesis will be vital for developing effective prevention, early detection, and treatment strategies, improving both survival and quality of life .
4. Techniques such as TLIF and MISS-TLIF show promising results for chordoma resection and spinal disorder treatment can be potential benefice by efficiently decompressing the spinal cord and vascular systems.
5. Improved survival rates and outcomes with adjuvant therapy, including proton beam therapy, have been observed, supporting a 5–10 year survival period post-surgery. This literature review emphasizes not only improved quality of life but also a variety of therapeutic methods that extend patient longevity and quality

of life.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Ethical Approval

Ethical approval was not required for this study because it is based exclusively on previously published data and does not involve human participants or animal experiments.

Consent for Publication

Not applicable.

Data Availability Statement

All data analyzed in this study are derived from previously published articles and are available within the cited references.

Author Contributions

All authors contributed to the conception, literature search, data analysis, manuscript preparation, and final approval of the manuscript.

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