

Cranioplasty Following Resection of Primary Intraosseous Meningioma: A Systematic Review with Descriptive Statistical Analysis of Reconstruction Materials, Timing, and Complications

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Abstract

Introduction

Primary intraosseous meningiomas (PIMs) are rare, extradural neoplasms of the calvarium that frequently require cranial reconstruction following resection. The existing literature consists of case-level reports, and no prior study has systematically analyzed cranioplasty materials and timing or their association with complications in this population. This systematic review provides the first pooled analysis of reconstructive outcomes following calvarial PIM resection.

Methods

This PROSPERO-registered (CRD420261356118), PRISMA-compliant systematic review searched PubMed, Embase, Cochrane Library, and Web of Science from inception through 3/27/2026. Inclusion required adult patients (≥ 18 years) with calvarial PIM undergoing cranioplasty, with reported material, timing, and outcomes (≥ 3 -month follow-up). Skull base and primary intradural meningiomas with secondary intraosseous extension were excluded. Two independent reviewers performed title/abstract and full-text screening with third-reviewer conflict resolution. The JBI Critical Appraisal Checklist assessed for risk of bias. Individual patient data were extracted and pooled for descriptive analysis.

Results

Thirty-three studies comprising 61 patients (45 female; mean age 53.0 years) and 68 cranioplasty events were included (mean follow-up 35.5 months). Most tumors were WHO Grade I (86.9%). Immediate reconstruction was performed using PMMA (57.8%), titanium mesh (25.0%), and PEEK (10.9%). Immediate reconstruction was performed in 94.1% of cases, and intraoperative molding was the predominant fabrication method (71.4%). 17/68 cranioplasty events (25.0%) were complicated, yielding 17 all-cause complications across 15 patients (24.6%). Complications occurred

in 21.9% of immediate and 75.0% of delayed reconstructions. Revision procedures were required in 10.3% of cranioplasty events (7/68). Tumors recurred in 14.3% of patients, with a mean interval of 30.7 months.

Conclusion

In this pooled analysis of case-level data, immediate cranioplasty was associated with a statistically significant lower associated complication rate compared to delayed reconstruction, though direct comparison is limited by differences in tumor characteristics and surgical context between groups. Nevertheless, our evidence suggests that delayed reconstruction should be approached with skepticism and could reflect a preference for delayed reconstructions in complex cases with inherently increased morbidity. In this instance, computerized reconstructive technology can be used to increase the feasibility of immediate reconstruction for complex tumors, potentially mitigating morbidity, though this claim remains untested. These findings provide the most comprehensive available data for surgical planning in this rare tumor population.