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Case Report
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Management of Surgery to Cranioplasty Reconstruction in Meningioma Patients with Hyperostosis: Case Series

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Abstract

Background: Meningiomas, common primary brain neoplasms, become more frequent with age. They can affect osseous structures, manifesting as hyperostosis and significantly diminishing the well-being of patients. Although meningiomas' precise etiology and pathogenesis remain ambiguous, hormonal influences and other factors have been implicated in their development. This study seeks to explain surgical management and cranioplasty reconstruction to reduce recurrence and improve the well-being of patients.

Objective: This case series encompasses a retrospective analysis of medical records from six patients diagnosed with meningiomas with hyperostosis, treated between December 2022 and January 2024, at Dr. Soegiri General Hospital, Lamongan. The analysis focuses on surgical interventions and cranioplasty reconstruction.

Cases Presentation: Six patients had chronic cephalgia and cranial masses persisting for 3-6 years. Computed tomography imaging revealed hyperostotic changes contiguous with the neoplastic lesions, prompting craniotomy. Subsequent acrylic cranioplasty was undertaken to ensure encephalic protection and to achieve cosmetic restoration.

Conclusion: For patients presenting with meningiomas and hyperostosis, symptomatic management through surgical excision and resection of the hyperostotic bone is recommended. Early implementation of cranioplasty, preferably acrylic materials, is recommended to shield cerebral structures and restore cranial morphology, given its economic feasibility and reduced infection risk compared to autologous bone grafts.

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INTRODUCTION

Meningiomas are neoplasms originating from arachnoid membrane cells within the leptomeninges, encompassing the arachnoid and pia mater [1]. These tumors are among the most prevalent intracranial neoplasms, representing the most significant proportion of primary brain tumors and benign central nervous system (CNS) tumors, with an incidence of 53.4%[2].

Although generally benign, meningiomas can significantly compromise patients' quality of life [3]. Their incidence increases with age, with the highest diagnosis rate at approximately 65 years [2]. The precise etiology of meningiomas remains uncertain; however, various conditions and risk factors have been implicated, including obesity, alcoholism, radiotherapy, hormonal factors, hormone replacement therapy, oral contraceptive use, breast cancer[4], and the administration of anti-androgen drug cyproterone acetate (CPA) at doses exceeding 10 mg [5], as well as radiation exposure[4,6].

In benign meningiomas, chromosomal aberrations typically involve focal deletions, whereas malignant meningiomas exhibit multiple chromosomal mutations[4]. Tumor progression and grade escalation are influenced by specific genetic mutations[4]. Chromosomal mutations implicated in meningioma predisposition include alterations in chromosome 22, particularly in neurofibromatosis type 2, and mutations in chromosomes 1p, 6q, 14q, and 18q[4]. Additionally, inherited genetic factors contribute to meningioma development, such as mutations in CREB binding proteins, Von Hippel-Lindau, and neurofibromatosis type 1[4]. Other genes implicated in meningioma pathogennesis include NF2, AKT1, TRAF7, SMO, PIK3CA, KLF4, SMARCE1, and subtypes such as BAP1, H3K27me3, TERT promoter, and CDKN2A/B [4].

The classification of meningiomas has evolved significantly with advances in technology. Initially proposed by Engert in 1900, the classification included four types: fibromatous, cellular, sarcomatous, and angiomatous [7]. This was later expanded by Russell and Rubinstein in 1971 to five types: meningothelial, fibrous, transitional, psammomatous, and angiomatous[7]. The most widely adopted classification, established by the World Health Organization (WHO) in 2007, delineates 15 types: meningothelial, fibrous, transitional, psammomatous, angiomatous, microcystic, secretory, lymphoplasmacyte-rich, metaplastic, choroid, clear cell, atypical, papillary, rhabdoid, and anaplastic[7]. The latest WHO update in 2021 categorizes meningiomas by type and grade (I, II, III) as part of the Central Nervous System Tumors classification [8]. Tumor grading reflects malignancy, with WHO grade I tumors being potentially curable via surgical resection, whereas grade IV tumors are highly malignant with poor prognoses[8]. The most recent classification approach based on DNA methylation is currently under development [9,10]. For this paper, the WHO classification system has been employed.

Patients with meningiomas present with a range of symptoms. One study identifies the most frequent to least frequent symptoms as cranial nerve dysfunction, weakness, visual disturbances, headaches, and gait abnormalities [11]. Contrarily, another study lists headaches, visual impairment, cognitive

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dysfunction, gait disturbances, and seizures in descending order of frequency [12].

The localization and size of meningiomas vary across studies. One investigation reported that most tumors were situated supratentorially [(13)]. Another study, focusing on patients not undergoing hormone therapy, identified meningiomas primarily in the parasagittal-falx region (17 patients), cranial base (10 patients), brain convexity (7 patients), and lateral ventricles (1 patient) [14]. Statistically, non-skull base meningiomas have a higher recurrence rate than those at cranial base locations [14]. Additional research found the most common tumor sites to be the cerebellopontine angle (40%), tentorial region (17%), petroclival area (15%), foramen magnum (14%), and convexity (14%) [11]. Meningiomas in the petroclival region, cerebellopontine angle, and foramen magnum are associated with increased postoperative complications [11]. Some meningiomas invade surrounding structures, such as adjacent bones, leading to hyperostosis [(15,16)]. The surgical prognosis for meningiomas is influenced by several factors, including the absence of comorbid conditions (e.g., hypertension, diabetes mellitus, chronic obstructive pulmonary disease), lack of visual impairment for six months, involvement of the optic canal, presence of hyperostosis on CT scans, tumor size greater than 5 cm, and patient age of 65 years or older [13,17–20]. Surgical mortality rates are reported at 1.72% [13].

This study aims to present a series of six meningioma cases with hyperostosis treated between December 2022 and January 2024 at Dr. Soegiri Lamongan Hospital.

CASE PRESENTATION

All patients reported chronic complaints of bumps on the head for durations ranging from 3 to 6 years. The patients were subsequently at the age of 41,47,46,45,44, and 55 years.

CASE 1:

The CT-Scan imaging demonstrates a hyperdense lesion in the fronto-temporo-parietal sinistra extra-axial region. Following imaging, an artificial skull reconstruction using acrylic was planned. The patient underwent a craniotomy for tumor excision, positioned supine with the head tilted to the left. The surgical site was disinfected with Savlon and Betadine. A horseshoe-shaped incision was made, layer by layer. Four burr holes were drilled, followed by a craniotomy. The bone flap was removed, revealing the tumor extending into the bone and dura mater. The tumor was excised with a 1 cm margin of healthy dura mater and sent to the Anatomical Pathology section for analysis. The dura mater was grafted with fascia, a Redon drain was placed, and the wound was closed layer by layer—the section of the cranium removed in the right temporoparietal region post-craniotomy. A month post-craniotomy, the patient underwent acrylic cranioplasty as showed at Figure 7. Positioned supine with the head tilted to the left, the surgical site was disinfected with Betadine. An incision was made along the previous scar, and the fascia was separated from the dura mater, revealing a cranial defect. Acrylic was molded to fit the bone defect and fixed at four points. The area was irrigated with NaCl, a Redon drain was placed, and the wound was closed layer by layer.

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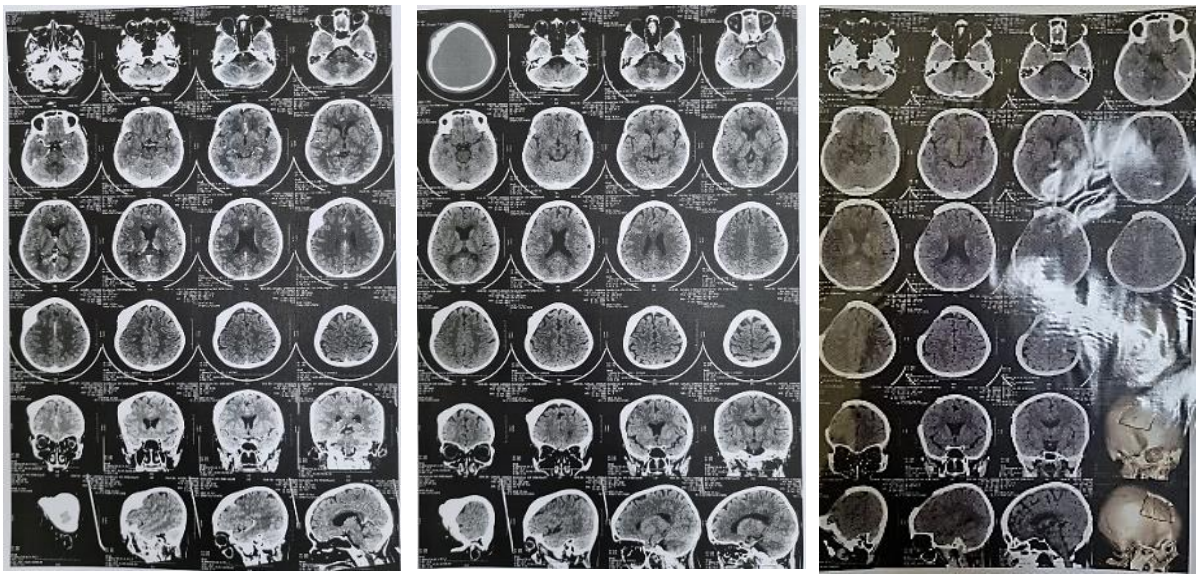
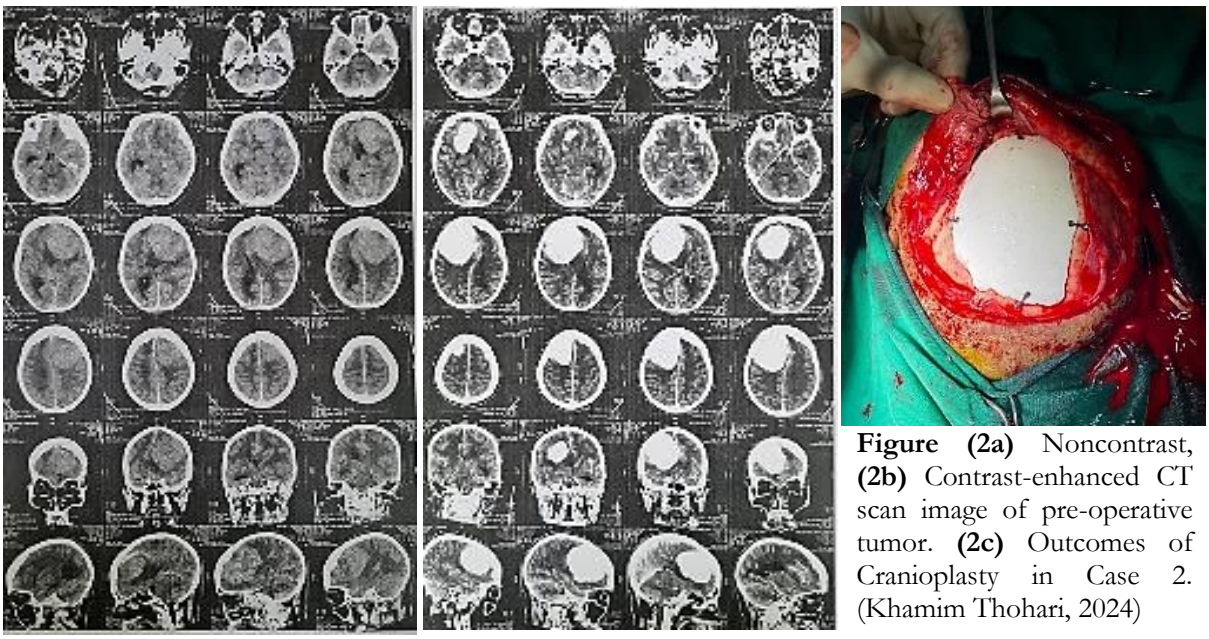


1a 1b 1c 1d

Figure (1a,b). Contrast-enhanced CT scan images of the pre-operative tumor, **Figure (1c)** post-craniotomy and tumor removal in Case 1. (Source: Khamim Thohari, 2023) **Figure 1d.** Outcomes of Cranioplasty in Patient from Case 1. (Source: Khamim Thohari, 2024).



2a 2b 2c

Figure (2a) Noncontrast, **(2b)** Contrast-enhanced CT scan image of pre-operative tumor. **(2c)** Outcomes of Cranioplasty in Case 2. (Khamim Thohari, 2024)

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CASE 2:

The CT-Scan imaging reveals hyperdense lesions in the left frontoparietal area and a noticeable midline shift. The patient underwent a tumor excision craniotomy, positioned supine with the head tilted to the right. The surgical site was disinfected with Savlon and Betadine. An extended temporoparietal incision was made. Three burr holes were drilled, followed by a craniotomy. The bone flap was removed, exposing the dura mater, which was then opened around the tumor. The tumor, with firm boundaries, was separated from the normal brain tissue. The tumor was resected, and the dura mater was grafted with fascia. A Redon drain was placed, and the wound was closed layer by layer. Subsequently, an artificial skull reconstruction using acrylic was planned. Two months post-craniotomy, the patient underwent acrylic cranioplasty. Positioned supine with the head tilted to the right, the surgical site was disinfected with Betadine. An incision was made following the previous scar, and the fascia was separated from the dura mater, revealing the cranial defect. Acrylic was molded to fit the defect and fixed at four points. The area was irrigated with NaCl, a Redon drain was placed, and the wound was closed layer by layer.

CASE 3:

Pre-operative non-contrast CT-Scan imaging shows the midline shift. and presence of a hyperdense lesion in the fronto-parietal sinistra. The patient underwent a tumor excision craniotomy. Positioned supine with the head tilted to the right, the surgical site was disinfected with Savlon and Betadine. A temporofrontal incision was extended, and the dura mater was opened, revealing the tumor. The tumor, which had firm boundaries, was meticulously separated from the normal brain tissue. Complete excision of the tumor was achieved. Hemostasis was ensured, and a subdural drain was placed. The dura mater was primarily sutured, and the wound was closed layer by layer. Subsequently, the patient underwent an artificial skull reconstruction using acrylic. A month post-craniotomy, the patient was scheduled for acrylic cranioplasty. Positioned supine with the head tilted to the right, the surgical site was disinfected with Savlon and Betadine. An incision was made along the previous scar, exposing a cranial defect measuring 15 x 10 cm. Acrylic was molded to fit the defect and secured with a 5-point fixation. The area was irrigated with NaCl, a Redon drain was placed, and the wound was closed layer by layer.

CASE 4:

The pre-operative CT-Scan contrast-enhanced shows a round-shaped hyperdense lesion in the left sphenoid-orbital region, with narrowed ventricles. During the surgery, the patient was positioned supine with the head tilted to the right. The surgical site was disinfected with Savlon and Betadine. An incision was made along the previous scar, followed by a craniotomy. Resection extended to the lateral orbital region. The dura mater was opened, and the tumor was excised. The dura mater was then grafted, a redon drain was placed, and the wound was closed layer by layer. A month post-craniotomy, the patient was scheduled for acrylic cranioplasty. During the procedure, the patient was positioned supine with the head tilted to the right. The surgical site was disinfected with Savlon and Betadine. An incision was made along the previous scar, and

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the fascia was separated from the dura mater. The acrylic was molded to fit the bone defect and secured. The area was irrigated with NaCl,

CASE 5:

The pre-operative CT-Scan non-contrast and contrast images show a hyperdense lesion in the temporal-parietal-occipital dextra area.

The patient underwent a craniotomy for meningioma excision. During the surgery, the patient was positioned supine with the head tilted to the left. The surgical site was disinfected with Savlon and Betadine. A horseshoe-shaped flap incision was made layer by layer, and four burr holes were drilled. A craniotomy was performed, and the dura mater was opened. The tumor was excised and left at 25%, ensuring hemostasis. The dura mater was grafted with fascia, a Redon drain was placed, and the wound was closed layer by layer.

a Redon drain was placed, and the wound was closed layer by layer.

Subsequently, an artificial skull reconstruction using acrylic was planned. Twenty days post-craniotomy, the patient was scheduled for acrylic cranioplasty. During the procedure, the patient was positioned supine with the head tilted to the left. The surgical site was disinfected with Savlon and Betadine. An incision was made along the previous incision, and the fascia was separated from the dura mater, revealing a cranial defect measuring 10 x 12 cm. Acrylic was molded to fit the bone defect and secured with a 4-point fixation. The area was irrigated with NaCl, a Redon drain was placed, and the wound was closed layer by layer.

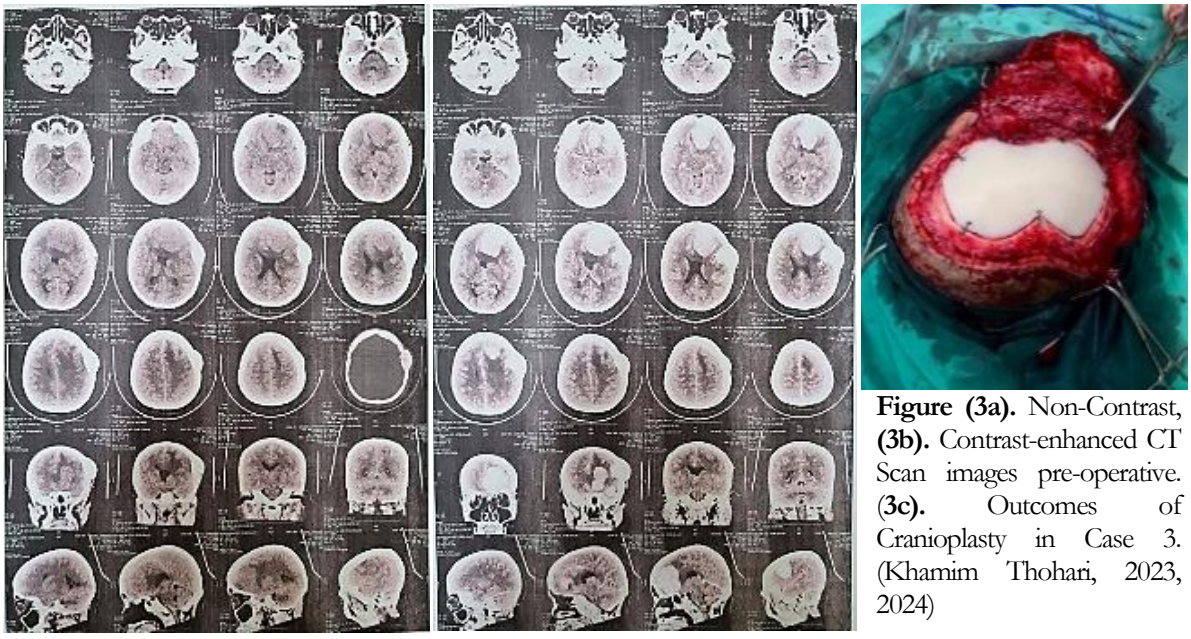

Figure (3a). Non-Contrast, **(3b).** Contrast-enhanced CT Scan images pre-operative. **(3c).** Outcomes of Cranioplasty in Case 3. (Khamim Thohari, 2023, 2024)

3a **3b** **3c**

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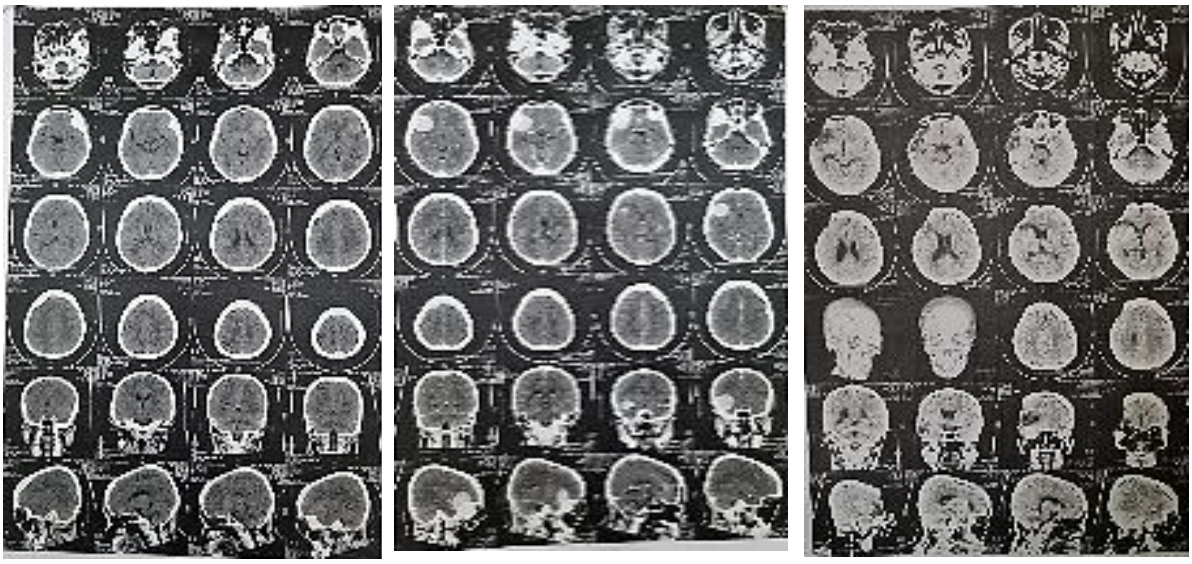
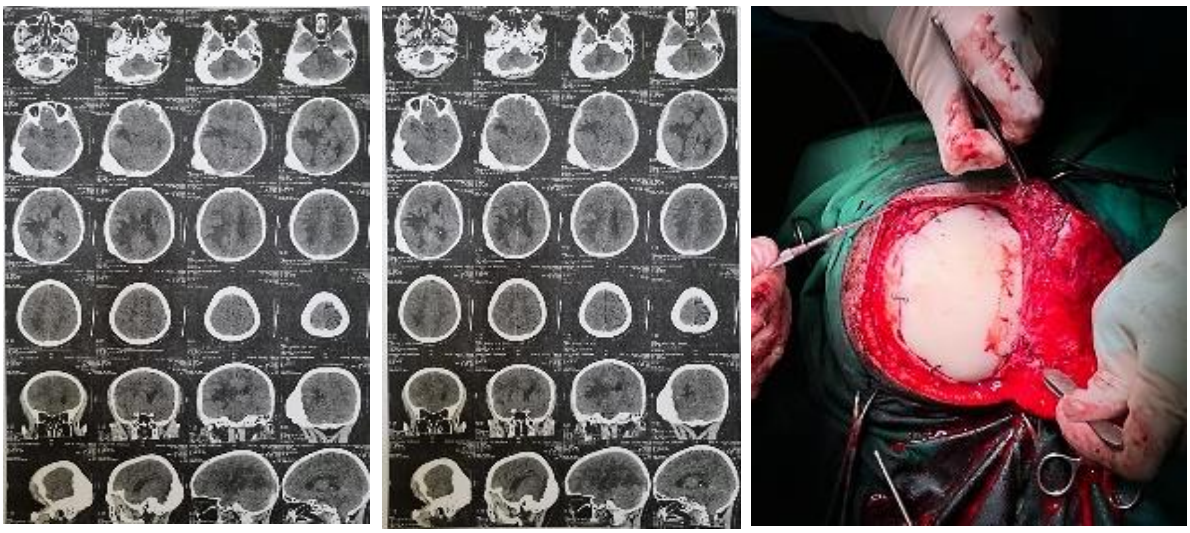
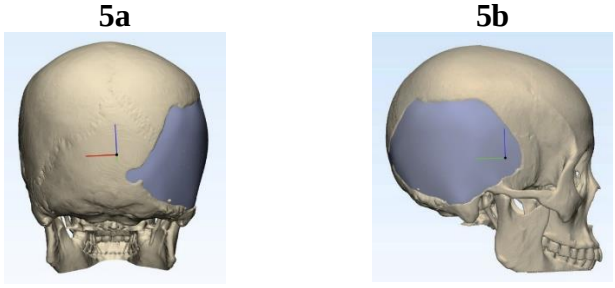


4a 4b 4c 4d

Figure (4a). Non-contrast, (**4b).** Contrast-enhanced CT scan image in the pre-operative assessment of tumor removal, (**4c).** Contrast-enhanced CT scan image post-operative assessment of tumor removal. (**4d).** Cranioplasty results for Case 4 patient. (Source: Khamim Thohari, 2023)



5a 5b 5c



5d 5e

Figure (5a). Non-contrast, (**5b).** Contrast-enhanced CT scan image in the pre-operative assessment of tumor removal. (**5c).** Outcomes of Cranioplasty. (**5d, e).** Cranioplasty 3D Imaging 3d in Case 5 Patient. (Khamim Thohari, 2023).

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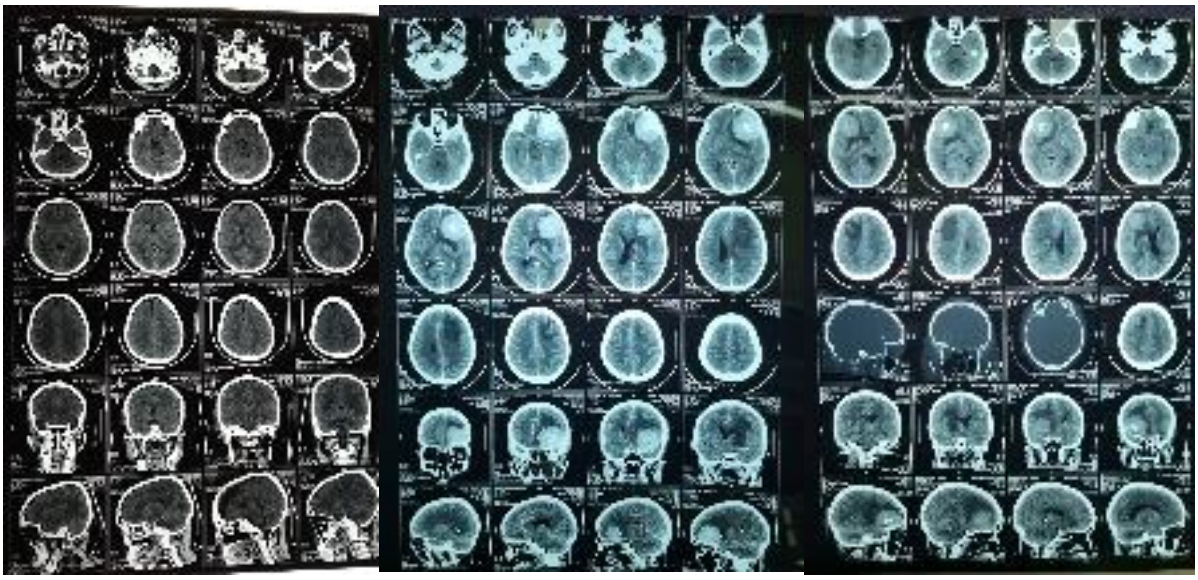

6a 6b 6c

Figure (6a). Non-contrast, (**6b,c).** Contrast-enhanced CT scan images of the pre-operative tumor in Case 6. (Source: Khamim Thohari, 2022)

CASE 6:

The pre-operative CT-Scan imaging demonstrates a hyperdense lesion in the sphenoid area. The patient underwent a tumor excision craniotomy, positioned supine with the head tilted to the right. The surgical site was disinfected with Savlon and Betadine. An incision was made. Four burr holes were drilled, followed by a craniotomy. Exposing the dura mater, which was then opened around the tumor. The tumor, with firm boundaries, was separated from the normal brain tissue. The tumor was excised, and the dura mater was grafted with fascia. A Redon drain was placed, and the wound was closed layer by layer. Subsequently, an artificial skull reconstruction using acrylic was planned. A month post-craniotomy, the patient underwent acrylic cranioplasty. Positioned supine with the head tilted to the right, the surgical site was disinfected with Betadine. An incision was made following the previous scar, and the fascia was separated from the dura mater, revealing the cranial defect. Acrylic was molded to fit the defect and fixed at four points. The area was irrigated with NaCl, a Redon drain was placed, and the wound was closed layer by layer.

DISCUSSION

The cohort of meningioma patients in this series had a mean age of 46.3 years, ranging from 41 to 55 years at the time of surgery. Statistically, the incidence of meningiomas escalates significantly in individuals aged 40 and above compared to younger cohorts [21]. This trend is corroborated by an Indonesian study that reported an average age of 47.92 years among female hormonal contraceptive users diagnosed with meningiomas [22].

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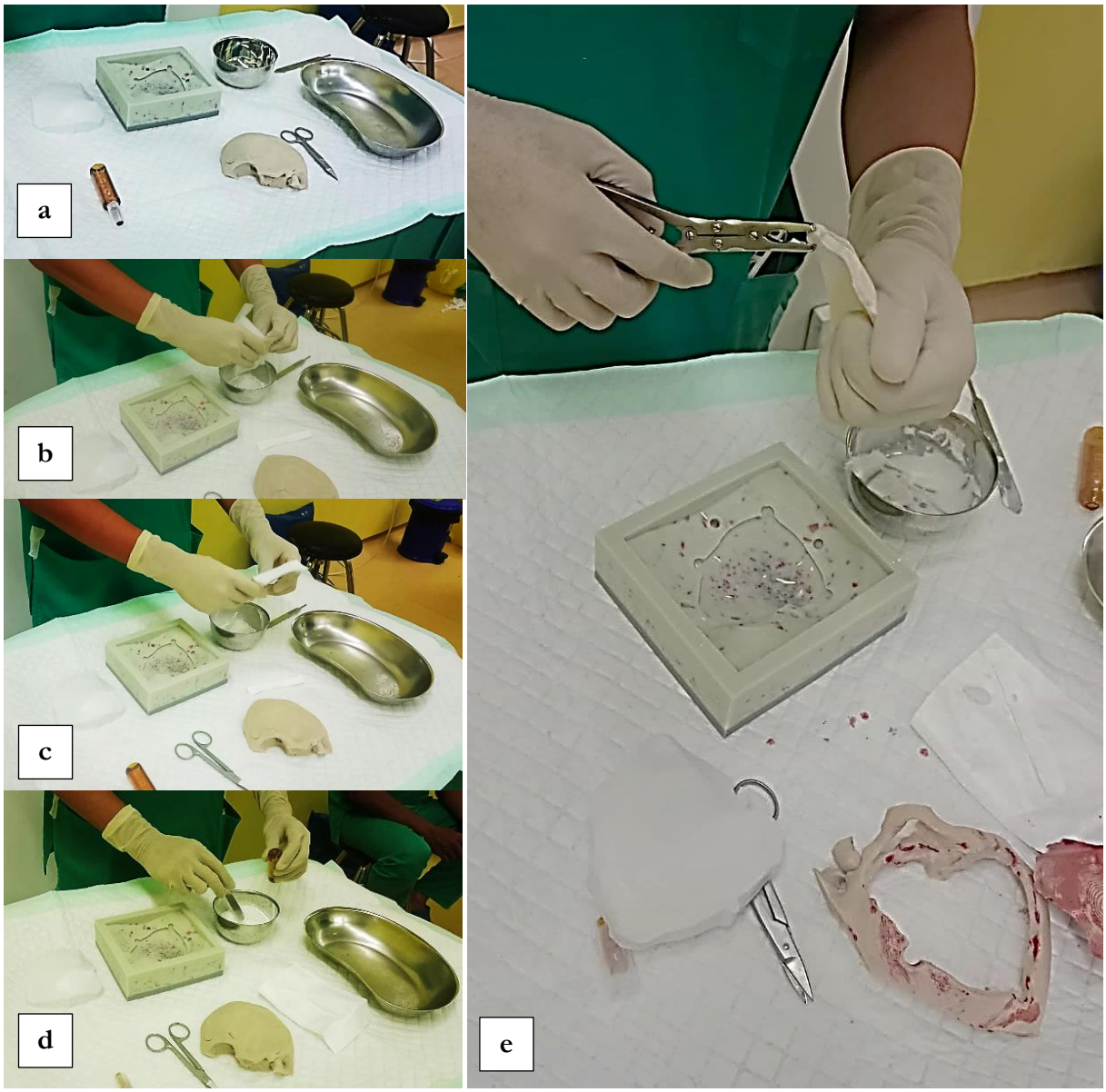

Figure (7a,b,c,d,e). Artificial Cranium Creation Process (Source: Documented by Khamim Thohari, 2023)

All patients in this study were female, consistent with the higher incidence of meningiomas observed in women compared to men. However, the precise etiological factors for this remain unidentified. One hypothesis implicates hormonal receptors, including those for progesterone and estrogen. In a study of 311 post-menopausal meningioma patients, those using hormone replacement therapy exhibited a heightened risk of meningiomas, with the risk increasing over the study period[23]. The study also noted a more significant risk associated with estrogen use compared to combined estrogen-progesterone therapy[23].

Further evidence from a study of 1,121 participants indicated that pre-menopausal women using oral contraceptives had a higher risk of developing phenobarbital meningiomas than non-users[24]. This finding is supported by another Indonesian study involving 99 patients, which found a greater risk of meningiomas among hormonal contraceptive users[22]. A separate investigation with 67

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participants revealed that progesterone-based contraceptives more frequently and rapidly led to meningioma recurrence compared to estrogen or combined estrogen-progesterone contraceptives[25]. Similar associations between estrogen, progesterone, and increased meningioma risk have been reported in other studies[26,27].

Research also indicates that long-term use of hormone replacement therapy, particularly estrogen-progesterone for over ten years, significantly raises meningioma risk[26]. Notably, patients who had used progesterone for an extended period and then discontinued it experienced tumor shrinkage[28]. A meta-analysis of 11 studies confirmed a higher meningioma risk in patients with a history of hormone therapy compared to non-users[29]. Additional risk factors include obesity, alcoholism, breast cancer, use of the antiandrogen drug CPA at doses over 10 mg [5], and radiation exposure[4,6].

All patients primarily presented with bumps and headaches persisting for 3 to 6 years, attributed to increased intracranial pressure [3]. Neurological deficits and seizures, depending on the meningioma location, were other common symptoms[3]. Upon CT scan, hyperostosis was evident, prompting surgical intervention. A study of 212 meningioma patients reported hyperostosis in 67 cases, predominantly at the lateral cranial base and sphenoid wing[30]. An Indonesian study identified the convexity, sphenoid, and intra-orbital regions as the most frequent meningioma sites[31].

Meningiomas affecting adjacent structures, such as hyperostotic bone, necessitate maximal resection of surrounding bones, typically via craniotomy[32]. The surgical objective is symptom relief, tumor growth cessation, and enhancement of patient quality of life [33]. Surgical risk assessments consider the patient's general health, tumor location, age, size, and presenting symptoms[33].

Several factors influence the outcomes of meningioma surgery. Favorable postoperative results (mRS 0-3) correlate with tumor sizes under 3 cm and the absence of comorbidities such as hypertension, diabetes, and COPD, whereas age and WHO grading are linked to recurrence[13]. Meningiomas causing visual symptoms have a better prognosis if symptoms are present for six months, preoperative visual acuity exceeds 0.5, no optic nerve atrophy or optic canal involvement, and hyperostosis is absent on CT scan[17]. Postoperative readmission risks are associated with CRP values over 0.5 mg/L, repeat surgeries, and underlying tumor metastases[34].

Larger meningiomas (≥5 cm) present a higher complication rate post-surgery [18]. Patients aged 55 and above with tumors less than 8 cm in diameter, predominantly aged 67 with WHO grade I meningiomas, showed a decline in quality of life, exacerbated by comorbidities as age increased[19]. Consequently, surgical decisions in older patients should consider individual characteristics, comorbidities, and functional status[19]. Advanced age in meningioma patients correlates with increased surgical complications and mortality. A study found significantly higher mortality and cardiorespiratory complications in patients aged 65 and above compared to younger cohorts[20].

In this series, all patients exhibited meningiomas with hyperostosis. A similar case study about meningioma identified MMP-1,

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MMP-2, MMP-9, and IL-6 expressions in hyperostotic meningiomas, unlike those without hyperostosis [35]. MMP-1, rarely seen in meningiomas, is associated with tumor malignancy and invasiveness, while MMP-2 and MMP-9 relate to peritumoral edema, recurrence, malignancy, and invasiveness. IL-6 is linked to peritumoral edema [35]. Interestingly, no progesterone receptor expression was detected[36]. Another case involving grade II meningioma with lipo metaplasia and hyperostosis reported favorable postoperative outcomes[35,36].

Subsequent cranioplasty was performed on all patients following craniotomy. Cranioplasty, involving repairing skull defects with alternative materials, primarily aims to protect the brain and improve aesthetics [37]. In this series, acrylic was utilized due to its cost-effectiveness and lower infection rates than autografts [38,39].

CONCLUSION

Meningiomas can impact adjacent structures, making skull hyperostosis detectable via CT scans. Common presenting symptoms include head bumps and headaches. Surgical excision of meningiomas and hyperostotic sections is recommended to halt tumor progression and minimize symptoms. Acrylic cranioplasty restores cranial integrity and aesthetics, effectively protecting the encephalon and restoring the skull's preoperative contour.

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