

**FIGURE 2.** (A) The tumor is composed by vessels, smooth muscle tissue, and adipocytes. Hematoxylin and eosin (original magnification 100 $\times$ ). (B) Positive immunostaining for Vimentin around the vessels and part of the spindle cells (original magnification 100 $\times$ ). (C) Positive immunostaining for smooth muscle actin on the vessel wall and part of the spindle cells (original magnification 100 $\times$ ). (D) Positive immunostaining around curved vessels for CD34 (original magnification 100 $\times$ ).

actin (Fig. 2C). Some vessels were positive for CD34 (Fig. 2D). Adipocytes were negative for S-100 protein.

## DISCUSSION

The AML is the most common benign neoplasm of the kidney. It has been reported infrequent in other locations, the liver being the most common among them. The most constantly reported sites in the oral region were the lips, hard palate, and buccal mucosa.<sup>5–7</sup> The diameter of AML varies from a few to 20 cm or more with a mean of 9 cm<sup>8</sup> but previous patients reported in hard palate are seen to be smaller than 1 cm<sup>1,3–5</sup> and the size of the tumor in our patient is remarkable.

The AML may appear in related with tuberous sclerosis complex, or as an individual disorder. In about half of the patients renal AMLs are associated with tuberous sclerosis, and these tumors are commonly multiple, bilateral, and related with cysts. In the oral cavity, only 1 patient was multiple and associated with tuberous sclerosis.<sup>5,7</sup> Although the renal AMLs are often invasive, they involve regional nodes and may recur, extrarenal AMLs are commonly well demarcated, show no recurrence, and may be easily removed.<sup>4,9</sup>

The histologic findings of the tumor is specific; however, sometimes AMLs may be mistaken for a liposarcoma because of the tumors big size, focal cellularity, and cellular pleomorphism.<sup>8</sup> Fibrosarcoma, leiomyosarcoma, rhabdomyosarcoma, malignant melanoma, fibrolipoma, plexiform neurofibroma, angiomyoma, and inflammatory or reactive processes should be considered to make the differential diagnosis.<sup>10</sup> It seems significant to increase the documentation of the tumors in the mouth to understand the etiology of oral AMLs.

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## The Pericranial Flap as a Salvage Procedure in Pediatric Neurosurgical Complications

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**Abstract:** The pericranium is a vascularized structure that can be used for the treatment of complex scalp and skull defects. It is also utilized as a prophylactic measure to prevent wound complications in high-risk patients. In this study, we looked at the use of the pericranial flap in pediatric patients. A retrospective chart review was done in the American University of Beirut Medical Center from February 2010 to 2020. Ten pediatric patients were identified who required either prophylactic pericranial flap ( $n = 3$ ) or for treatment of a chronic draining sinus ( $n = 7$ ). Patients were followed up for an average of 23 days. There were no cases of infection, hematoma, seroma, or meningitis. Only 1 case developed dehiscence of the skin. It was managed conservatively and healed within 2 weeks. The pericranial flap is a workhorse flap for scalp and skull reconstruction, with no donor site morbidity and thus should always be considered.

**Key Words:** Complex wound, draining sinus, pediatric, pericranial flap

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Craniotomies and craniectomies are readily performed neurosurgical procedures for a wide array of etiologies including traumatic brain injuries, intracranial decompression, and tumor resection.<sup>1</sup> Complications from these procedures may arise. Wound and soft tissue infection, wound breakdown, bone infection, cerebrospinal fluid leakage, and chronic draining sinuses are possible complications that may warrant intervention from the reconstructive surgeon.<sup>2</sup> Treatment of scalp and skull defects can be challenging, partly because of the inelasticity of the surrounding tissue and partly because of previous incision that compromises the axial blood supply.<sup>3</sup> The presence of foreign material, hardware, and bone grafts may further add to complexity of the wound.<sup>4</sup> Basic principles of treatment include removal of infected material and providing the wound bed with a highly vascularized tissue that is able to hasten wound healing.<sup>5</sup> Because of these various factors, creating a proper treatment algorithm for the management of scalp and skull defects is difficult. Even though free tissue transfer has been well reported for the treatment of complex scalp wounds in adults,<sup>6</sup> their use in pediatric patients, especially those below the age of one year, is still somewhat limited. The pericranium is a technically feasible procedure that can provide a stable coverage with minimal donor site morbidity.

The pericranial flap is a workhorse flap for the treatment of complex scalp and skull defects. The pericranium is a layer of connective tissue similar to the periosteum of long bones that is thick, pliable, and has a rich vascular network, making it ideal for the use as a flap in cranial reconstructions.<sup>7</sup> The pericranium receives its blood supply from various anastomosing arteries including the supraorbital, supratrochlear, superficial temporal, posterior auricular, and occipital.<sup>8</sup>

In this article we will discuss the use of the pericranial flap to salvage complicated scalp wounds in pediatric patients. We will report our experience with the pericranial flap and its efficacy in providing well-vascularized tissue to a damaged wound bed to help promote wound healing.

## PATIENTS AND METHODS

After obtaining Institutional Review Board approval that conforms to the Helsinki Declaration, a retrospective review was conducted on all pediatric patients who underwent pericranial flap reconstruction of scalp wounds from February 2010 to February 2020 at the American University of Beirut Medical Center. The aim of this study is to identify the pediatric patients only who underwent reconstruction of the scalp or skull with a pedicled pericranial flap. Inclusion criteria were patients from 0 to 18 years of age who underwent an array of neurosurgical procedures including craniotomy or craniectomy for trauma or tumor resection or insertion of a ventriculoperitoneal shunt with a resulting complicated wound that needed reconstruction with a vascularized pericranial flap. Complicated wounds were characterized by infection, dehiscence, and cerebrospinal fluid leakage. We also included patients who underwent pericranial flap as a prophylactic procedure to prevent wound complications if the patient was at high risk of that. Patients were excluded from the analysis if they were adults or previously reconstructed with flaps other than pericranial flaps.

Patients satisfying the inclusion criteria were identified and relevant data were extracted from the electronic medical records. Data collected included patient demographics such as age, sex, medical comorbidities and preoperative conditions including previous neurosurgical procedures, location of previous scalp incisions, neoadjuvant chemotherapy or radiation therapy, presence of open scalp wound or draining sinus, infection, and cerebrospinal fluid leakage. We also gathered information about the defect such as size, composition, location, and the presence of alloplastic implants.

Pericranial flap properties were also collected including the number of flaps and the pedicle used.

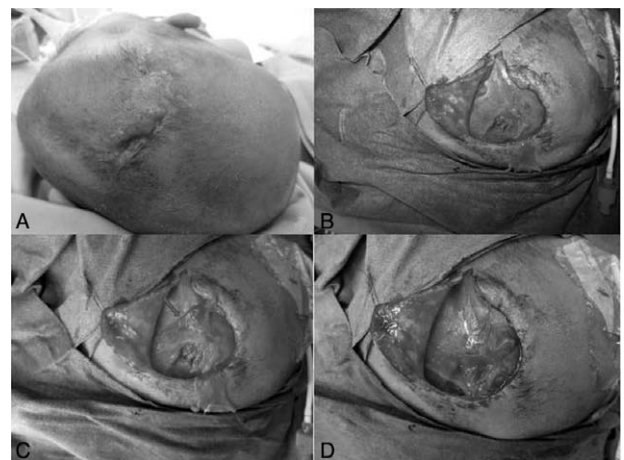
Outcomes, follow-up, and complications were recorded. Complications ranged from wound dehiscence, cerebrospinal fluid leakage, infection, hematoma, seroma, intracranial infection to meningitis.

## RESULTS

### Patient Demographics

We identified 10 pediatric patients who underwent reconstruction of the skull or scalp with vascularized pericranial flap after neurosurgical procedures (Supplemental Digital Content, Table 1, <http://links.lww.com/SCS/B593>). The mean age was 7.8 years, with a range from 6 months to 18 years. There were 3 males and 7 females. The primary etiologies were trauma ( $n=4$ ), tumor ( $n=2$ ), infected ventriculoperitoneal shunts ( $n=2$ ), encephalomalacia ( $n=1$ ), and osteopetrosis ( $n=1$ ). Only 1 patient received preoperative chemotherapy and radiotherapy.

Seven patients presented with an infected nonhealing wound, with one of them developing meningitis. Three of the aforementioned patients had concomitant leakage of cerebrospinal fluid. One of these patients had multiple infected ventriculoperitoneal shunts and the affected area was large and so 2 separate pericranial flaps were needed to cover the area (Fig. 1). Three patients were classified as high risk for complications and underwent the procedure as a prophylactic precaution to decrease the risk of wound complications. The first patient was scheduled for a fourth redo craniotomy and had received radiotherapy and so a pericranial flap was warranted. Similarly, the second patient had a fifth redo craniotomy and had previously an infected polyetheretherketon implant that was removed. We opted for a pericranial flap to avoid any further complications. The third patient presented with an open frontal bone and orbital roof fracture requiring placement of hardware and a titanium mesh. Since the reconstruction was done acutely and the viability of the skin flaps was not certain, a pericranial flap was placed to protect the hardware.



**FIGURE 1.** (A) Six months' old with craniosynostosis causing increased intracranial pressure necessitating a ventriculoperitoneal shunt placement that was complicated with an infection. Shunt removal and debridement alone failed to achieve wound healing. (B) The defect after debridement of the infected tissue. The first pericranial flap is seen. This flap was used to plug the bone defect created by the burr hole. (C) A second pericranial flap (at the arrow) was raised to be placed over the first one to provide a well-vascularized coverage below the long incision line. (D) After both flaps were inset with complete coverage.

## Surgical Technique

A standard approach to the harvesting was done. The flap was harvested from the craniotomy incision planned by the neurosurgeon. A small incision on the contralateral side of the skull was sometimes needed to release the pericranium and allow for its mobilization.

Usually, a trapezoidal shape of the flap was raised, with the flap kept attached to the pedicle. The galea was occasionally included in the flap to provide more thickness. The flap was either based anteriorly on the supratrochlear and supraorbital arteries ( $n = 3$ ), laterally on the superficial temporal artery ( $n = 3$ ), or posteriorly on the occipital artery ( $n = 4$ ).

Next, the flap was inset in a tension-free manner to cover both the bone at craniotomy site and skin incision. It was sutured with absorbable monofilament. The skin was closed primarily in all cases over a suction drain.

## Outcomes

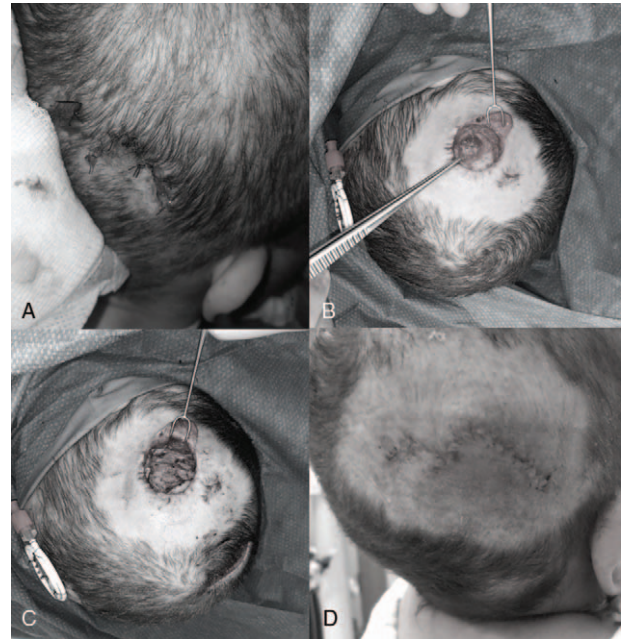
The mean follow-up time was 23 days. We had no cases of seroma, hematoma, infection, or meningitis (Supplemental Digital Content, Table 2, <http://links.lww.com/SCS/B593>). Only 1 patient developed wound dehiscence at the level of the skin only that was treated conservatively and healed within 2 weeks. This patient had a previous craniotomy for a gunshot wound that was complicated by wound infection. The pericranial flap was used as to provide vascularized tissue to treat the infection. The patient underwent reconstruction of the bony defect as a second stage after 1 year using methyl methacrylate. He had no further complications.

## DISCUSSION

Soft tissue infection and osteomyelitis leading to chronically open wounds and draining sinuses of the scalp are devastating complications in neurosurgery. Living with a chronically open wound can have detrimental effects on pediatric patients from both an infective and a psychologic standpoint. Classic options of reconstruction include secondary healing, local advancement flaps, tissue expanders, and free flaps.<sup>9</sup> In the setting of a wound complicated by an infection, cerebrospinal fluid leakage or osteomyelitis surgical options is limited to pericranial flaps or free tissue transfer. In pediatric patients, pericranial flaps should be the first choice. Even though microsurgical procedures are now well-established in children, an attempt at a less complex reconstruction should be the starting step.

The scalp is composed of 5 layers: the skin, subcutaneous tissue, galea aponeurosis, loose areolar tissue otherwise known as the subgaleal fascia, and the pericranium.<sup>10</sup> The pericranium and subgaleal fascia constitute the pericranial flap. For a thicker flap, the galea could be incorporated.<sup>11</sup> The pericranial flap is well vascularized receiving robust blood supply from superficial temporal, supratrochlear, supraorbital, posterior auricular, and occipital vessels and from vessels arising from the underlying cranial bones.<sup>12</sup> It is this unique and broad vascularity of the pericranium that allows it to be a versatile flap. The flap can be pedicled anteriorly, laterally or posteriorly. If larger and longer flaps are required, the flap can be bipedicled, ensuring a more stable blood supply.<sup>13</sup>

The flap could be used prophylactically to avoid wound complications in high-risk patients, or it could be used in the treatment of a complex scalp wounds. In patients with risk factors that contribute to cranioplasty or craniotomy complications such as secondary surgery, radiotherapized scalp, or medical comorbidities, the flap could be used to prevent subsequent complications.<sup>14</sup> One study by Gordon et al specifically addresses prophylactic



**FIGURE 2.** (A) Three-year old with multiple ventriculoperitoneal shunt infection. Treated by debridement and an attempt at primary closure that failed. Presenting with a discharging sinus. (B) After thorough debridement of the infected tissue. Note the bony defect from the Burr hole. (C) The pericranial flap inset to obliterate the bone defect and provide vascularized tissue at the incision line. (D) At 2 weeks' follow-up with complete wound healing.

pericranial onlay flaps, and has reported a significant improvement in outcomes, morbidity, infections, and cost when the flap was used in secondary cranial reconstruction.<sup>15</sup> In our series, we had 3 patients in which the pericranial flap was used in the prophylactic setting. All patients healed well, with no wound breakdown or infection.

Nonetheless, the real role of the pericranial flap comes to play in complicated scalp wounds. Postoperative wound breakdown, bone exposure, nonhealing ulcer, and soft tissue and bone infection can significantly impact the patient's prognosis and health.<sup>16</sup> They cannot be treated as minor events; their management is often complex and in need of a multidisciplinary approach.<sup>17</sup> The pericranial flap can be the ideal flap to treat such problems. By first proper debridement of the infected surgical site and removal of devitalized and granulation tissue, the pericranial flap can be inset allowing proper wound healing to take place.<sup>18</sup> Seven of our patients had chronic draining sinus at the craniotomy incision site. After proper surgical debridement, the pericranial flap was inset and the skin was closed primarily. In 6 of the 7 patients, wound healing was achieved, and no infection developed. In only 1 patient, the skin dehisced but the pericranium was well covering the bone, preventing bone exposure. Secondary healing was achieved in 2 weeks with conservative wound care.

Having alloplastic implant material in the surgical bed will complicate the treatment approach.<sup>19</sup> Regardless of the material used, having synthetic material in an infected wound bed will increase the risk of infection and preclude proper wound healing.<sup>20</sup> Typically, when such a scenario occurs, the implant needs to be removed. An attempt can be made to salvage of the implant; adequate debridement followed by coverage with well vascularized tissue.<sup>21</sup> In three of our patients, the implant was salvaged, and proper wound healing was achieved.

Finally, because of the pliability of the pericranium, it can be used to plug small defects in the cranium that are complicated by either infection or leakage of cerebrospinal fluid.<sup>22</sup> That was found to be useful in 2 of our cases; both patients developed complications at the site of the ventriculoperitoneal shunt opening in the cranium. The flap was used to plug the burr holes, thus providing a stable and vascularized coverage for the area of exposed dura (Fig. 2).

An advantage to our study is that we were able to select a uniform group of patients who are of the same age group and have the same complicated scalp wound etiology. We have shown that the pericranial flap was successfully used to treat complex and infected scalp wounds that have previously failed other forms of treatment. All of the patients healed with no complications. The pericranial flap is a workhorse flap in scalp reconstruction and should be always considered. It maximizes coverage with vascularized tissue, has no donor site morbidity, and has decreased downtime for the patient.

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## Endonasal Transpterygoid Surgery for Adult Mature Teratoma in the Sphenoid Bone

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**Abstract:** Teratomas are germline tumors commonly composed of multiple cell types derived from embryonic germ cell layers. Teratomas in head and neck region are exceptionally rare and present during the neonatal and infantile period. We describe a male adult with a mature teratoma originating from sphenoid body. A 24-year-old male patient presented with left-sided intermittent headache and facial numbness. Radiographic imaging showed a 3 cm × 2.3 cm mass with heterogeneous density in the sphenoid region. The endoscopic sphenoid sinus opening surgery was performed through endonasal transpterygoid approach. The final pathologic diagnosis was confirmed as mature teratoma. The patient has been followed-up for 18 months without recurrence. We suggest endonasal transpterygoid approach could be an effective and safe treatment for patients with mature teratoma in the sphenoid bone.

**Key Words:** Adult teratoma, endoscopic sphenoid sinus surgery, sphenoid bone

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