

The Adjunctive Applications of Integra[®] in Free-Flap Surgery to the Scalp: A Two-Case Experience

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Abstract: Free flaps for scalp reconstruction occasionally traverse the face to reach the recipient vessels in the neck if the superficial temporal vessels are unavailable and vein grafts are circumvented. When using the latissimus flap, the facial skin at the exposure incision is not redundant enough to cover the proximal flap. Integra[®] (Integra LifeScience) can be applied to cover the exposed portion of the flap containing the vascular pedicle, expediting completion of the operation without the need to perform immediate skin grafting. If flap perfusion is marginal, the surgeon is relieved of the concern for autologous skin graft loss if flap perfusion worsens. After flap perfusion is secured, a skin graft is applied over the neodermis regenerated by Integra. We describe two cases utilizing Integra as an adjunctive skin substitute for coverage of the exposed portion of the flap containing the pedicle, thus obviating the need for immediate skin grafting.

Keywords: adjunct, free flap, integra, scalp, reconstruction, vertex

Introduction

The Integra[®] Dermal Regeneration Template (Integra Life Science Corporation, Plainsboro, N.J., USA) is a bilaminate synthetic construct consisting of an outer silicone layer and an inner collagen-glycosaminoglycan matrix that serves as a scaffolding for the growth of the neodermis. The impermeable silicone layer closes the wound and prevents fluid egress until the dermal regenerative template is ready for skin grafting three–four weeks later.^{1,2} The FDA approved Integra for use in extensive burns with insufficient donor tissue for coverage. Since then, its use has broadened, and it has become a staple along the reconstructive ladder. Numerous successful reports have been published on the use of Integra paired with a split-thickness skin graft for scalp reconstruction.^{3–5}

Free flaps are another common reconstructive tool in scalp reconstruction, especially for defects containing exposed and poorly vascularized bone, repaired dura, and cranioplasty. Common donor sites include the latissimus dorsi (LD) muscle or musculocutaneous flap, which can cover large scalp defects.⁶ The use of the superficial temporal artery (STA) and accompanying vein (STV) has proven to be reliable recipient vessels.^{7,8} However, the STA and STV are frequently not available or usable secondary to previous radiation or surgical intervention(s). The paucity of adjacent or nearby recipient vessels requires interposition vein grafts to the vessels in the neck. To avoid vein grafts, an appropriate free flap can be chosen such that the vascular pedicle starts at the upper neck or lower face to allow anastomosis to the facial artery, and vein, or another artery and vein in the neck. This means that the free flap must traverse upward across the face, anterior to the ear, in order to reach the scalp defect. Instead of harvesting a split-thickness skin graft, the exposed muscle containing the vascular pedicle can be expediently covered with Integra, accelerating the completion of the operation. In the event of a postoperative perfusion deficit in the free flap, the potential for loss of the autologous skin graft is eliminated. In the event of take-back, the incision over the pedicle is released and microvascular intervention restores perfusion to the flap. Subsequently, the released incision is not closed completely, and the dermal regeneration template (Integra) is applied to the secondary skin defect to prevent pedicle compression. A skin graft is subsequently performed

on the neodermis provided by the dermal regeneration template (DRT) once free-flap viability is assured. These adjunctive applications of Integra have been demonstrated in two case reports of free-flap reconstruction of the scalp vertex.

Case I

An 83-year-old male underwent removal of a fibrous malignant skin/soft-tissue tumor followed by 6 weeks of post-operative radiation 7 years prior to presentation. PET scan was negative for metastatic disease. He has past medical history of type 2 diabetes mellitus, hypertension, left bundle branch block, obesity (BMI 33.47 kg/m²), and a distant 25-pack-year smoking history. He was born with a right upper limb deficiency accompanied by ipsilateral latissimus muscle atrophy. He developed a non-healing wound in the vertex of his scalp 4 years after radiation, which involved a 3 cm area of desiccated calvarium and failed to heal despite wound center care, including hyperbaric oxygen therapy. His wound physician referred him to a private neurosurgeon who performed debridement of the calvaria down to the dura over a 1.5 cm diameter. The neurosurgeon attempted to cover the 5 cm scalp defect with quadruple fan flaps, which necrosed (Figure 1A). The patient was then referred to a plastic surgeon (senior author) with a 22×8 cm area of the scalp eschar. The full-thickness skull defect was small, and the secondarily exposed dura was intact. A relaxing incision of 5×2 cm was present on the left lateral parietal scalp, which was amenable to skin grafting.

Because he was born with a right upper limb deficiency, his right latissimus muscle was atrophic. Consequently, the left latissimus dorsi (LD) was selected as the free flap. His left superficial temporal arterial signal was faint, and the accompanying venous signal was indistinct on pencil Doppler. Preoperatively, the left facial artery and vein were chosen as recipient vessels. The latissimus musculocutaneous flap was designed by harvesting the muscle to its origin with a long skin island 22 cm long and 7–8 cm wide distally based on the flap. A preauricular incision was made connecting to the scalp wound, and his left superficial temporal vessels were explored, but proved unusable owing to the lack of a recipient vein. Facial skin was incised from the preauricular incision to the mandibular border. The free flap pedicle, which was dissected proximal to the thoracodorsal artery, was divided and tunneled through a 3 cm-wide skin bridge at the jaw line and anastomosed to the left facial vessels along a submandibular border incision. End-to-end anastomoses between the subscapular and facial arteries and between the accompanying veins were uncomplicated. The LD traversed superficial to the SMAS (superficial musculoaponeurotic system) across his face anterior to his ear for the vascular pedicle to reach his submandibular incision; this exposed muscle measured 22 cm × 5 cm. To expedite the completion of

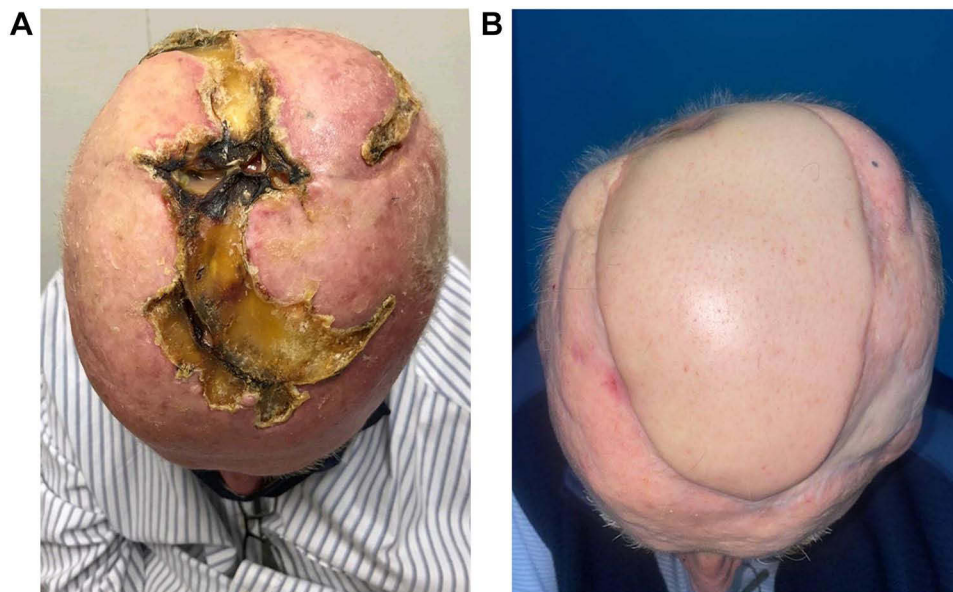


Figure 1 (A) Preoperative bird's eye view taken 7 weeks after failed quadruple fan flaps performed by the referring neurosurgeon. This photo was taken at the patient's initial presentation to the plastic surgeon (first author). (B). Postoperative bird's eye view at 3 years and 5 months after free tissue transfer.

surgery, the exposed LD muscle was covered with Integra Meshed Bilayer Wound Matrix. Initially, a tie-over-bolster was placed to immobilize the Integra graft; however, the LD skin island became pale and reverted after bolster removal. A layer of Xeroform gauze (DeRoyal, Powell, Tennessee) was applied over DRT to avoid any compression of the vascular pedicle. **Figure 2** shows the viability of both the flap and Integra at 2 weeks postoperatively. However, he developed flap tip necrosis 4×4 cm over the occiput, which required surgical intervention.

At two months postop (**Figure 3**), much of DRT epithelialized. The swelling at the surgical site resolved, and early atrophy of the muscle flap developed. The original skin defect covered with DRT now needed a 14 cm × 4 cm skin graft, which is a 50% reduction in autologous skin requirement. His 4 cm diameter area of the exposed occiput secondary to flap-tip necrosis required two sessions of burring of the outer cortex with DRT placement, subsequent full-thickness skin grafting, and eventual adjacent tissue transfer before complete closure (**figure 4** and **1b**).

Case 2

The second case involved a 79-year-old male who underwent Moh's surgery on the vertex of his scalp to remove an atypical fibroxanthoma on his scalp vertex, followed by radiation therapy. Nine months later, he presented with a non-healing 8 cm diameter wound that was unresponsive to hyperbaric oxygen therapy (**Figure 5a**). An MRI showed osteomyelitis of the exposed skull. This patient had notable comorbidities including coronary cardiac disease, chronic obstructive pulmonary disease, and pulmonary fibrosis due to cigarette smoking and firefighting. He used 2 liters of nasal cannula oxygen at home, as needed. The patient completed preoperative pulmonary and cardiac clearance. A team-based approach was planned for neurosurgery and plastic surgery. The neurosurgeon performed an 8-cm diameter craniectomy and titanium mesh cranio-plasty. The defect was covered by a senior author with an anterolateral thigh free flap (**Figure 6**), 8 cm in width and 23 cm in length, with a vascular pedicle length of 13 cm, which allowed easy access to the left superficial temporal vessels. The unused distal portion of the flap was discarded. The microvascular anastomoses were uneventful, despite the below-average diameters of the donor and recipient vessels. On postoperative day 2, the ALT flap developed ischemic changes, and the patient returned to the OR for re-exploration, which identified pedicle compression without thrombosis. Restoration of blood flow required full-length adventitial dissection of the vascular pedicle. Owing to the swelling and prevention of recurrent compression, the incision at the cephalad end of the parietal scalp over the proximal ALT vascular pedicle was left



Figure 2 Lateral postoperative photo at 2 weeks post free flap. Integra Meshed Bilayer Wound Matrix covers the previously exposed latissimus dorsi (LD) muscle, which receives blood supply from the facial vessels to the musculocutaneous component covering the mid scalp and scalp vertex defect. Minor microbial colonization is visible under the silastic layer of the dermal regeneration template (DRT). Regeneration of neodermis, which is tan-colored, has already formed.



Figure 3 Lateral view at 2 months postoperative. The silastic outer layer of the Integra was removed early at 2 weeks postoperative due to colonization. Robust epithelialization over the DRT is present, with early muscle atrophy of the flap and reduction in adjacent swelling.

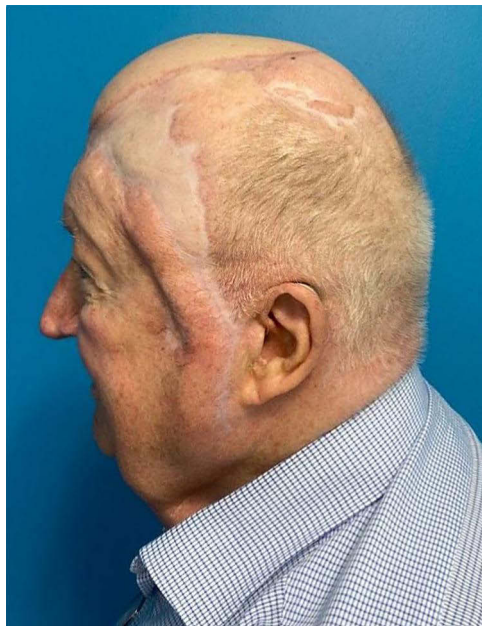


Figure 4 Postoperative lateral view at 3 years and 1 month after the LD free flap.

open. Two secondary 2.5 cm by 2 cm and 1 cm by 2.5 cm adjacent wounds were resurfaced with Integra Meshed Bilayer Wound Matrix. This flap survived except for the triangular part, which demarcated. Four weeks later, the necrotic skin over the proximal vascular pedicle of the flap was excised and the secondary defect was covered with unmeshed Integra of 8.5 cm by 3.5 cm (figure 7–8 at 6 days postop). In addition, a 3 cm by 0.75 cm strip of DRT was applied to the debrided anterior border of the flap. Given his co-morbidities and stable residual wounds, a staged skin graft was performed 131 days (about 4 and a half months) later, at which time the residual open surface area of the required DRT measured only 4 cm by

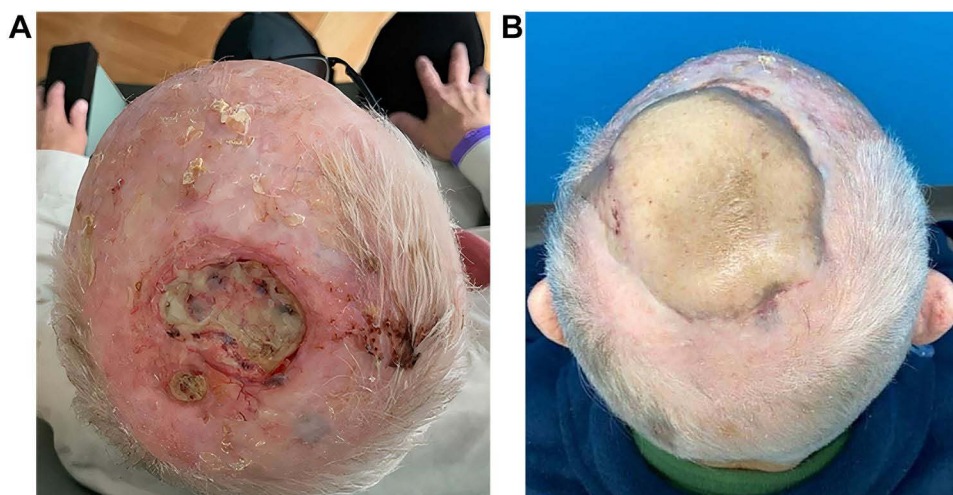


Figure 5 (A). Preoperative bird's eye view of patient 2, presenting at 9 months post-radiation with exposed calvaria at the apex of his scalp. This preoperative photo was taken at his initial presentation to the plastic surgeon (first author). **(B).** Postoperative bird's eye view at 6 months and 20 days after free flap surgery.

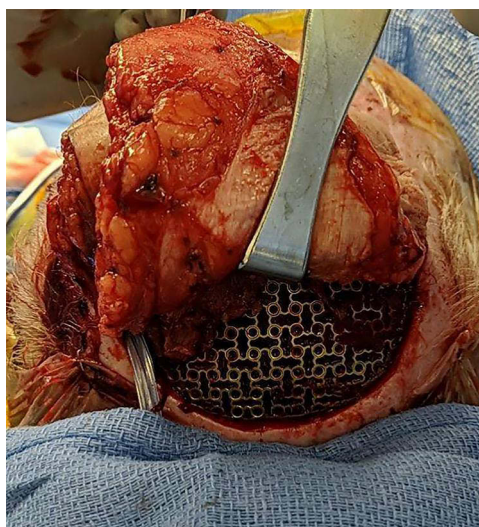


Figure 6 Intraoperative photo showing revascularized anterolateral thigh (ALT) flap during inset to cover a large titanium mesh cranioplasty after craniectomy of infected calvaria.

2.5 cm, which was a reduction in autologous skin requirement of 70% (Figure 9). Figure 5b shows postop bird's eye view of the flap at 6.5 months after the free flap.

Thirteen months later, the titanium mesh was removed because of infection. Figure 10 shows a photo 13.5 months after cranioplasty explantation, which was 2 years and 3.5 months after the free flap. The ALT flap coverage remained stable.

Discussion

Achieving coverage of scalp wounds can pose a formidable challenge, and the approaches vary depending on the complexity of the defect and expertise of the surgeon. Scalp reconstruction is approached hierarchically based on the well-known principle of the “reconstructive ladder” relative to the characteristics of the defect.⁹ Free-tissue transfer is often required for significant scalp defects involving exposed calvaria, dura, brain, and/or cranioplasty, chronic osteomyelitis, and a history of radiation.^{10,11} Maximizing the flap territory is crucial for achieving the distant reach of a free flap, particularly for scalp defects on the vertex. In the case of the latissimus flap, as demonstrated in our first case,



Figure 7 Postoperative left top lateral view 6 days post Integra placement following debridement of a demarcated, triangular portion of the ALT flap over its pedicle. Note the viable, healthy Integra with its transparent silastic membrane (outer layer). The underlying bovine collagen and chondroitin-6-sulfate is pink to red in color and has not yet formed neo dermis.



Figure 8 Bird's eye view to complement Figure 7 showing the relative location of the DRT placed over the ALT flap pedicle, which was exposed after flap take-back.

extending the harvest of the muscle and positioning the skin island more distally can significantly enhance the flap's reach. Similarly, in our second case, including the maximum number of perforators in the flap should be a fundamental objective, as it is in any anterolateral thigh (ALT) flap harvest for vertex scalp defects.¹²

Selection of adequate recipient vessels plays a key role in the success of the free tissue transfer.⁷ In situation in which the superficial temporal vessels are no longer employable as a result of previous ablation, radiation, or poor quality or caliber, selection of alternative recipient vessels on the contralateral side¹³ or in the neck is likely necessary.⁷ However, these alternative vessels are located at a much greater distance from the primary defect that makes the length of the pedicle a limiting factor. Use of vein grafts is an alternative option but is associated with increase anastomotic thrombosis rate.¹⁴ Maricevich et al in a retrospective study demonstrated that the free flap compromise rate was 14.5% with vein



Figure 9 Left top lateral view at 4 months and 10 days after flap debridement and Integra placement. Note the size of the DRT needing skin graft has reduced significantly (by approximately 70%) with epithelialization. Notice the tan-color transformation of the DRT, which now contains neo dermis and is ready for skin grafting.



Figure 10 Follow-up postoperative bird's eye view at 2 years and 3.5 months after the ALT flap reconstruction. The patient is also 13.5 months post removal of titanium mesh without a repeat attempt at cranioplasty.

grafts and 3.4% without vein grafts ($p < 0.001$).¹⁵ A free flap with a longer pedicle or longer axis can be employed to allow for the distal flap to reach the scalp defect. Such a flap reach is challenging for any defect located on the mid scalp and/or vertex of the head, as presented in our first patient. The proximal half of the LD muscle was used as a carrier of blood from the facial artery and vein across the preauricular region. This necessitates skin graft coverage of the exposed muscle of the flap. Skin graft is a simple procedure; however, in an advanced elderly patient with major co-morbidities and oozing tendency, within the context of an already long surgery by a solo surgeon, application of Integra emerged as an adjunct procedure to complete the operation expediently. When confidence in uncomplicated flap perfusion is lacking, a secondary concern arises for subsequent significant skin graft loss in the event of flap failure. The sizable area that required skin grafting over the muscle was 110 cm². In this situation, the use of a DRT instead of autologous skin graft obviated the potential for any skin graft loss and prevented any delayed healing and pain at the split-thickness skin graft (STSG) donor site. As demonstrated, when free flap perfusion is guaranteed over time, STSG can be performed as a staged, controlled procedure. Integra is typically ready for skin graft coverage 3 weeks after application,^{16,17} but additional delay diminished the surface area requiring skin grafting and allowed more time for our octogenarian to recover before undergoing another general anesthesia. DRT epithelializes well after neo dermis has developed.¹⁸ In our

first case, the skin graft requirement was reduced by 50% after waiting 2 months before skin grafting. The residual skin defect was amenable to a full-thickness skin graft harvested from the groin, obviating the need for a STSG donor wound.

The application of dermal substitutes, such as Integra, has been well reported in the literature as a viable option in the management of complex scalp wounds.¹⁹ However, to our knowledge, the literature is devoid of articles describing the adjunctive use of Integra for the coverage of muscle free flaps or exposed secondary skin defects after re-explorations. In our second case report, Integra was employed to expediently cover a secondary wound when a portion of the incision over the pedicle could not be re-sutured and when a portion of the flap was demarcated and debrided near the pedicle. When a DRT, as opposed to a skin graft, is used, the presence of a bolster dressing is not paramount. Albeit Integra is expensive,²⁰ its failure to take does not carry the same burden as loss of a piece of native skin.²¹ The lack of a bolster obviates any compression over the pedicle, which is critically important for flaps with precarious blood flow.

The literature has scarcely reported the complementary use of Integra²¹ as an adjunct in scalp free flap reconstruction. The application of Integra over the vascular pedicle has been reported in free flaps to the lower extremities,^{22,23} face,²⁴ and scalp.²⁵ Our second case describes a similar scenario in which the pedicle was in jeopardy of exposure requiring immediate graft coverage. Integra provided a reliable skin substitute to allow time for the flap to re-perfuse and demarcate, and additional revision surgery was anticipated. Leclère advocated preemptive application of Integra over lower extremity free-flap pedicles to avoid skin tension and compression at the level of the pedicle.²² Furthermore, he posited that a hematoma at the level of the pedicle will be highly visible due to color change of the Integra.

As an alternative to Integra, numerous other dermal substitutes are available on the market. Hill et al (2022) conducted a risk-benefit review of 11 dermal substitutes, encompassing both synthetic and biological options.²⁶ While DRT has proven to be versatile, its cost must be considered in the broader context of healthcare delivery. According to Jou et al, a 100 cm² DRT graft can cost several thousand dollars.²⁷

Our two case reports demonstrate the adjunctive use of Integra in complicated free-flap reconstruction of a defect occupying the mid-scalp and/or vertex in two advanced elderly patients with major comorbidities. Although the use of Integra for a plethora of wound types has been popularized, there have not been numerous reports describing the complementary use of Integra in free-flap reconstructions. The utility of skin-substitute applications described in this article is based on limited personal observations and a small number of publications. As is advocated by Karamitros et al when commenting on the validity of a clinical research study,²⁸ large-scale studies are necessary to confirm the benefits of DRT applications as described in the scenarios presented in this report.

Conclusion

We demonstrated two cases in which Integra was used as a tool to complement the complicated free-flap reconstruction of complex scalp defects on the top of the head. When a long muscle flap is required to reach the recipient vessels in the neck, Integra provides expedient grafting of the exposed muscle conduit. Similarly, this DRT can be rapidly applied to secondary skin defects that cannot be closed tension-free over the pedicle after reexploration. In a salvaged free flap, time is required for reperfusion and demarcation. Therefore, an additional benefit of DRT application for residual secondary wounds is that it eliminates the need for autologous skin grafting in cases of wound bed ischemia. While our paper highlights situations where the adjunctive use of DRT can be valuable, large-scale studies are needed to confirm our conclusions and improve long-term outcome assessment.

Ethical Approval and Consent

Ethical approval is not required to publish the case details in accordance with local or national guidelines. The hospital does not require ethical clearance for case reports. Written informed consent (Taylor & Francis Consent Form) for publication of their details, which includes photographs, was obtained from the two patients presented.

At our institution, no IRB is required for case series of 3 or fewer patients. Refer to Institutional Policy on Case Reports.

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Disclosure

The authors report no conflicts of Interest in this work.

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