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Cryopreserved Total Skin Allografts From Living Donors for Complex Wound Management: A New Paradigm in Regenerative Wound Care

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ABSTRACT

Skin allografts are essential in managing complex wounds, yet their availability is limited by low post-mortem donation rates. Skin harvested during body contouring surgeries offers a novel and sustainable source to expand tissue supply. We conducted a retrospective descriptive study at the Tarapacá Skin and Tissue Bank from January 2022 to December 2024. All donations from body contouring surgeries were processed as cryopreserved total skin allografts following national tissue banking standards. Variables included donor demographics, harvested area, units produced, microbiological results, and discard rates. To describe clinical performance, we present our group's initial clinical series of treated patients. From 248 living donors (mean age 41.3 years), 81 293 cm^2 of skin generated 2050 units. The discard rate was 27%, mainly due to a storage failure and isolated microbial contamination. Clinically, all patients achieved complete initial graft take, followed by gradual necrotic eschar formation at an average of 21 days. Eschar removal revealed vital tissue firmly adhered to the recipient bed, rich in fibroblasts and neovascular structures. Subsequent management included either escharectomy with split-thickness autografting over the neodermis, or spontaneous eschar lysis and skin regeneration, with the graft functioning as a dermal regenerator. This model increases tissue availability while providing allografts with both coverage and dermal regenerative properties.

1 | Introduction

Skin allografts (SA) are a fundamental therapeutic resource in the management of complex wounds, as they provide temporary biological coverage that protects against infection, regulates fluid loss, reduces pain, decreases systemic catabolism, and promotes tissue regeneration [1, 2]. Historically, their use has been closely associated with burn centres, where their indication is most frequent. However, their clinical application has progressively expanded to other conditions, such as chronic and complex wounds, which also benefit from this therapeutic approach [3–6].

[Correction added on 7 September 2025, after first online publication: The author's name, Jaime Masìa, has been corrected to Jaume Masìa.]

Abbreviations: CTSA, cryopreserved total skin allografts; IDTS, integrated donation and transplantation system; SA, skin allografts; TGC, tissue generation center; TSA, total skin allografts; TSTB, Tarapacá skin and tissue bank.

Summary

- Living donor skin from body contouring surgery is a sustainable and replicable source of allografts.
- Residual tissue can be processed into cryopreserved total skin allografts (CTSA), unlike traditional split-thickness grafts from cadaveric donors.
- From 248 donors, 2050 CTSA units were produced with low contamination rates; most discards were due to a single storage failure.
- In 10 patients, CTSA achieved initial graft take and promoted neodermis formation rich in fibroblasts and neovascularization.
- CTSA can serve as intermediate coverage later completed with an autograft, or as definitive coverage by stimulating dermal regeneration.
- This model reduces reliance on cadaveric donation and offers a cost-effective alternative to dermal regeneration matrices.

Skin banks play an essential role in the collection, processing, preservation, and clinical distribution of these tissues. Traditionally, SA are obtained from cadaveric donors as split-thickness grafts [7, 8]. However, the availability of cadaveric skin remains limited, particularly in low- and middle-income countries, due to cultural, logistical, and religious barriers that contribute to low post-mortem donation rates. In light of these limitations, the search for alternative sources of skin has become an urgent need [9].

In this context, a donation model based on living donors has emerged, using residual skin tissue generated during body contouring procedures [10, 11]. This strategy enables the production of cryopreserved total skin allografts (CTSA), which retain the full dermis and preserve biological viability [12]. The aim of this study is to describe the accumulated experience in the development and implementation of a skin bank based exclusively on living donor contributions obtained from surgical waste generated during body contouring procedures, the process leading to the development of CTSA, and the clinical outcomes derived from their use.

2 | Materials and Methods

2.1 | Skin Bank Activity Study

A retrospective, descriptive, cross-sectional study was conducted to evaluate the activity of the Tarapacá Skin and Tissue Bank (TSTB) between January 1, 2022, and December 31, 2024. The study population included all living skin donors whose tissues were obtained from surgical waste generated during body contouring procedures and subsequently processed at our facility. Data were extracted from the Integrated Donation and Transplantation System (IDTS) database of Chile and included donor age, sex, preoperative diagnosis, procured skin surface area (cm^2), number of processed graft units, microbiological testing results, and tissue discard rates. All procedures and protocols were performed under the supervision of the National Coordination for Organ and Tissue Procurement and Transplantation of the Chilean Ministry of Health. The activities were carried out under sanitary authorization granted by the Regional Health Authority (*Seremi de Salud*) of Tarapacá and approved by the Ethics Committee of the Tarapacá Health Service (ACTA SEC SSI No. 3/2022) [13].

2.2 | Clinical Series

To describe the clinical use of cryopreserved total skin allografts, we present the first clinical study published by our working group, conducted prior to the skin bank activity evaluation. Between November 2020 and February 2021, CTSA implants were performed in the enrolled patients, followed by a planned postoperative follow-up period. However, this follow-up was partially interrupted due to restrictions and logistical limitations imposed by the SARS-CoV-2 pandemic. This series documents the initial clinical outcomes of patients treated with CTSA produced from living donor skin obtained during body contouring procedures [12].

3 | Development of the Donation and Processing Workflow

The skin donation model for living donors undergoing body contouring surgery is structured in several stages, described as follows (Figure 1):

1. Donor selection: After completing the medical evaluation and confirming the indication for body contouring surgery, the plastic surgeon invited the patient to donate redundant skin from the dermal-fat flap. If the patient agreed to participate, a tissue donation questionnaire was completed, taking into account the exclusion criteria (Figure 2), and informed consent was obtained. This includes authorisation for serological testing to minimise the risk of infectious disease transmission (Figure 3). At this point, the coordination team at the TSTB is notified to register the case in the IDTS, arrange delivery of the donation kit (Figure 4) to the clinic or hospital where the procedure will take place, referred to operationally as the Tissue Generation Center (TGC), and coordinate the subsequent transfer of the donated skin to the TSTB.

2. Body contouring surgery and skin procurement: Skin procurement was performed in the operating room during the same surgical procedure by the same surgical team (Figures 5 and 6). The aseptic and antiseptic measures were identical to those applied during surgery. During anaesthesia induction, laboratory tests and serological samples (sample 2) were collected and stored for 5 years to allow retrospective investigation in the event of adverse reactions. Additionally, a 1 cm^2 skin biopsy (sample 3) was collected for aerobic, anaerobic, and fungal cultures, considering the initial sample of the process.

3. Packaging and labeling: Once the dermal-fat flap was resected, it was rinsed with saline to remove blood residues and placed in a sterile 90-μm bag containing saline, gentamicin (80 mg), and

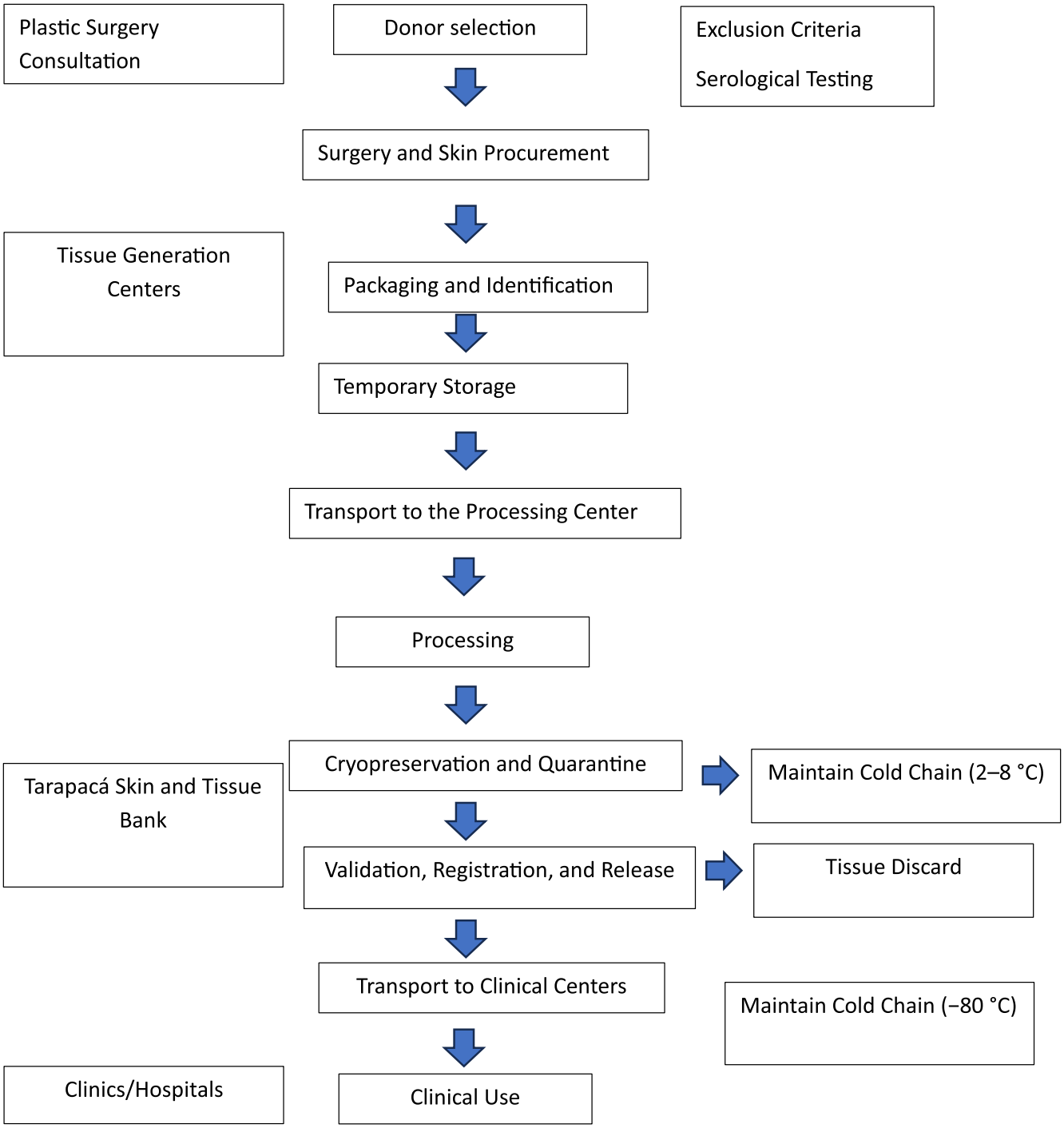

FIGURE 1 | General workflow overview of the Tarapacá skin and tissue bank.

cloxacillin (1 g) to ensure that the tissue was fully submerged. The primary bag was then sealed inside for a second, followed by a third. A label was inserted between the second and third bags, including donor information, date, time, and TGC. All bags were hermetically sealed to ensure maximum air removal.

4. Temporary storage: The packaged skin is transferred from the operating room to a refrigerator for temporary storage using a cooler with cold packs to maintain the cold chain (2°C–8°C).

5. Transport to the processing center: Within 36 h of procurement, the skin was transferred from the TGC to the TSTB using a designated transport company, maintaining the cold chain (2°C–8°C). The transported materials included the following:

- Insulated container with cold packs o Labelled skin specimen.
- Serology samples.
- Serological storage samples.

Microbiological culture samples o documentation including:

◦ Tissue donor questionnaire

1) Due to Infectious Diseases
   a. Patients with a history of or who are carriers of HIV/AIDS
   b. Patients with a history of hepatitis B or C
   c. Patients with active tuberculosis
   d. Patients diagnosed with syphilis or positive VDRL
   e. Patients diagnosed with HTLV I and II
   f. Patients diagnosed with Chagas disease
   g. Patients diagnosed with rabies, congenital rubella, or malaria
   h. Patients diagnosed with untreated bacterial or fungal endocarditis
2) Due to Central Nervous System Diseases
   • Degenerative diseases
   a) Any type or manifestation of dementia
   b) Alzheimer's disease
   c) Parkinson's disease
   d) Multiple sclerosis
   e) Creutzfeldt–Jakob disease
      • Infectious diseases
      a. Bacterial encephalitis
      b. Viral, fungal, or parasitic meningitis
      c. Bacterial meningitis
      d. Progressive multifocal leukoencephalopathy
      e. Subacute sclerosing panencephalitis
      f. Active viral encephalitis or encephalitis of unknown origin
      g. Fungal or parasitic encephalitis
3) Due to History of Cancer and/or Tumors
   a. History of neoplasia, except in situ cervical cancer
   b. Lymphadenopathy lasting more than one month
   c. Lymphomas, lymphosarcomas
   d. Leukemias
   e. Metastases from primary or secondary malignant tumors (lung, breast, cervical, colon, prostate, squamous cell carcinoma, melanoma, lymphoma, leukemia, CNS tumors, etc.)
4) Due to Other Medical Conditions
   • Patients treated with growth hormone
   • Patients with hemophilia
   • Patients undergoing prolonged corticosteroid therapy
   • Patients with acute burns covering more than 20% of body surface area
   • Any suspicious cutaneous lesion
5) Due to Behavioral Risk Factors
   • High-risk sexual behavior
   • Intravenous drug use (including intramuscular and subcutaneous routes)
   • Individuals engaged in sex work
   • Incarcerated individuals
   • Individuals with tattoos or body piercings within the last 6 months
   • Individuals for whom sexual behavior history cannot be assessed
6) Due to Skin-Specific Criteria
   • Skin contaminated with toxins
   • Pyodermitis
   • Any infectious, traumatic, or vascular skin lesion
   • Psoriasis
   • Epidermolysis bullosa
   • Loxoscelism

FIGURE 2 | Exclusion criteria for skin donation.

- Hepatitis B surface antigen
- Hepatitis C antibodies
- HIV antibodies
- VDRL (Venereal Disease Research Laboratory test)
- HTLV I and II
- Chagas disease

Intraoperative cultures:
a. Standard (aerobic) culture
b. Anaerobic culture
c. Fungal culture

FIGURE 3 | Intraoperative testing for skin donors.

- ◦ Signed informed consent
- ◦ Procurement protocol
- ◦ Human tissue transport protocol

6. Processing: At the TSTB, the dermal-fat flap was removed from the transport bag and processed in three stages: (a) Defatting: Performed manually with surgical scissors, preserving the entire dermis to obtain total skin allografts (TSA) (Figure 7). (b) Preparation: The flap was measured, shaved if necessary, sectioned according to clinical requirements, and subjected to washing cycles to reduce microbial load. A second culture sample was obtained (the first was intraoperative). The tissue was then immersed in a cryopreservation solution (10% glycerol) for 1 h. (c) Packaging and labeling: The resulting sheets are trimmed, measured, and labelled with all required traceability information. During this stage, samples 3 and 4 were collected for culture, along with an additional backup sample (sample 5).

7. Cryopreservation and quarantine: The allografts were cryopreserved using 10% glycerol as a cryoprotectant and stored at −80°C, resulting in serial cultures (quarantine period). The final product of this process was a CTSA (Figure 8).

8. Validation, registration, and release: Once laboratory and culture results are negative, the tissue is irradiated (25–28 kGy). Before release, all records of donation, procurement, and processing stages were reviewed within the IDTS system.

Category	Item	Quantity
Supplies for Flap Packaging	Physiological Saline 500 ml	3
	Gentamicin 80 mg	1
	Cloxacillin 500 mg	2
	Distilled Water 10 ml	2
	Syringe 10 ml 21G	2
	Sterile 90 µm Bag	3
	Bag Tie	3
Supplies for Skin Sample	Sterile 100 cc Urine Bottle	2
Supplies for Blood Samples	EDTA Tube for Viral Antibodies, HIV Determination	1
	EDTA Tube: Hepatitis B+VHC, HTLV I-II, Chagas	1
	Tube with Gel Separator and Coagulation Activator: VDRL	1
	Tube with Gel Separator and Coagulation Activator: Serology	2
	Thermal Envelope	1
Supplies for Transport	Laboratory Styrofoam Box	1
	Refrigerant Units (Gel Pack 15 x 19 cm)	7

FIGURE 4 | Living donor skin donation kit.

9. Distribution: Once cryopreserved, CTSA is transported to clinical centres for therapeutic use. Transportation requires dry ice (−80°C) to preserve the integrity of the cold chain.

10. Clinical use: The primary clinical indication for CTSA implantation was the coverage of complex wounds with exposure of critical structures such as bone, cartilage, or tendons, as well as wounds with impaired healing potential. Each recipient signed informed consent prior to the implantation of CTSA, and all data were recorded in the IDTS system to ensure biovigilance and traceability. Before implantation, each CTSA was rinsed three times with warm saline to remove residual cryoprotectants. The recipient bed was prepared through escharectomy and/or surgical debridement of necrotic, devitalised tissues and areas of disorganised granulation. The CTSA was then secured with sutures and/or staples, and in some cases, negative pressure wound therapy was applied as an adjunct. To achieve optimal graft take, the recipient site was required to meet the same criteria as for an autologous skin graft:

i. Adequate vascularisation
ii. Absence of active bleeding
iii. Absence of excessive exudate
iv. Absence of infection
v. Proper immobilisation of the CTSA.

When requesting allografts, the surface area to be covered and the primary contraction phenomenon inherent to full-thickness skin grafts was considered. This contraction results in a reduction in size immediately after procurement but recovers at the time of clinical application. CTSAs were transported on dry ice (−80°C) and thawed immediately before surgery. They were packaged in a double sterile pouch; the outer pouch was opened,

and the inner pouch removed aseptically. After rinsing, the graft was applied immediately. If the CTSA was not used, it could not be refrozen and was discarded.

4 | Results

4.1 | Skin Bank Activity Study

Between January 1, 2022, and December 31, 2024, the TSTB-processed skin was obtained from 248 donors, of whom 245 were female and 3 were male, with a mean age of 41.3 years (range: 17–73 years). All donations corresponded to surgical waste from 242 abdominoplasties and 6 reduction mammoplasties (Table 1). This yielded a total processed surface area of 81 293 cm^2 and 2050 skin allograft sheets. The annual distribution is as follows: in 2022, donations from 64 donors yielded 20 651 cm^2 of skin and 649 sheets; in 2023, 124 donors provided 36 020 cm^2 and 936 sheets; and in 2024, 60 donors contributed 24 621 cm^2 and 465 sheets (Table 2).

Tissue was discarded in 67 donors (27%), mainly due to a single, isolated failure in the storage system caused by a power outage and malfunction of the backup generator, along with isolated cases of microbiological contamination with pathogenic microorganisms in skin culture samples (Table 3).

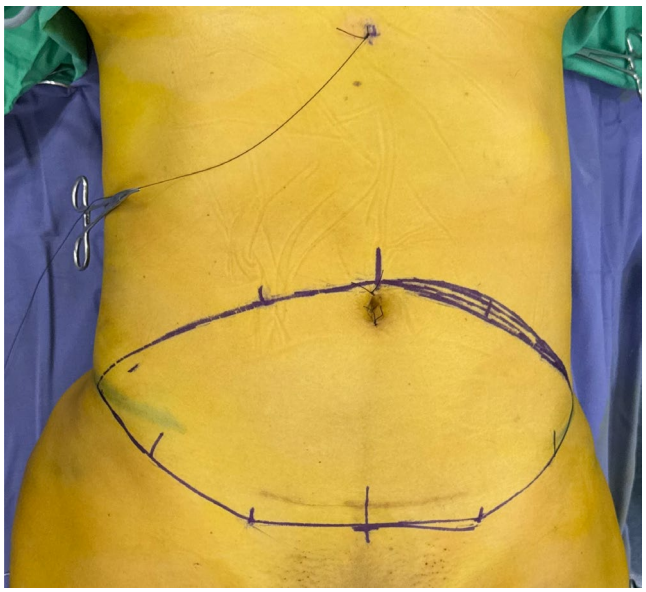

FIGURE 5 | Preoperative marking for abdominoplasty.

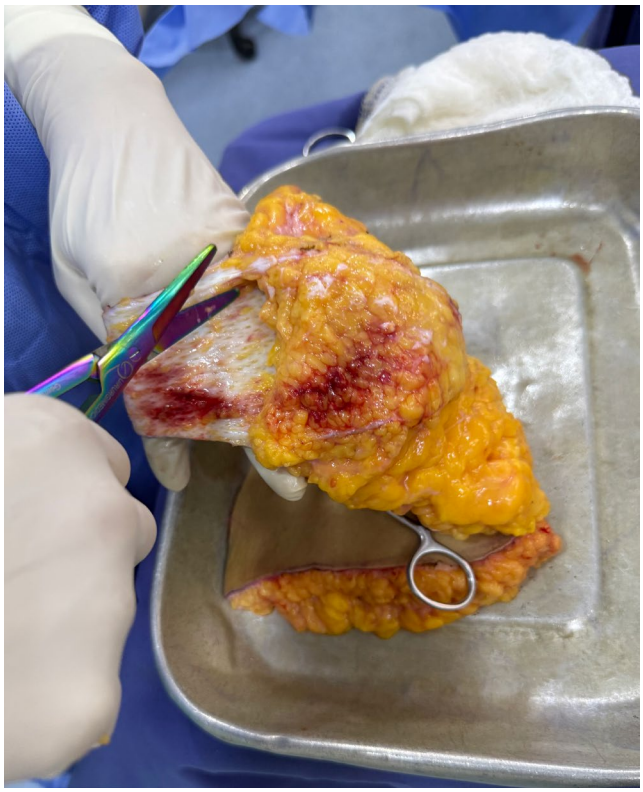

FIGURE 7 | Manual defatting of dermal-fat flap using surgical scissors.

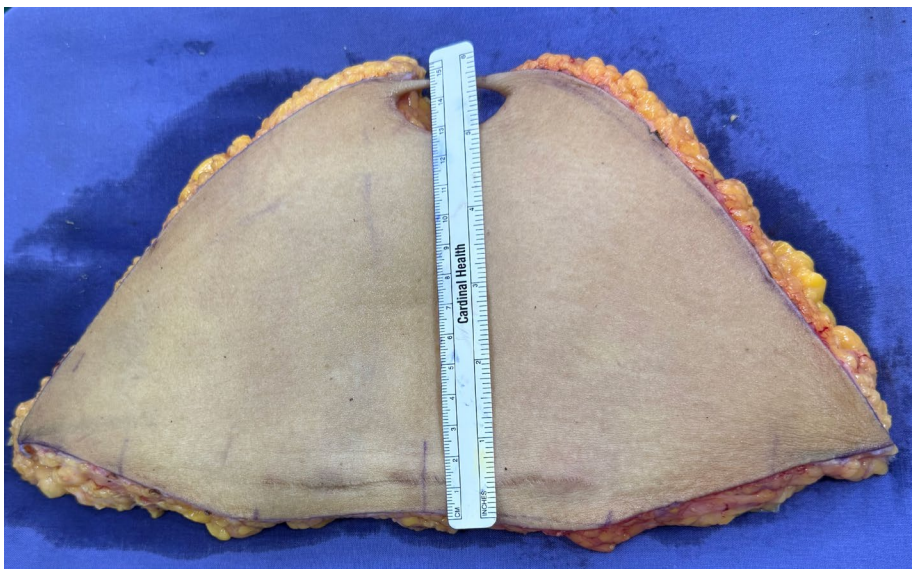

FIGURE 6 | Resected dermal-fat flap following abdominoplasty.

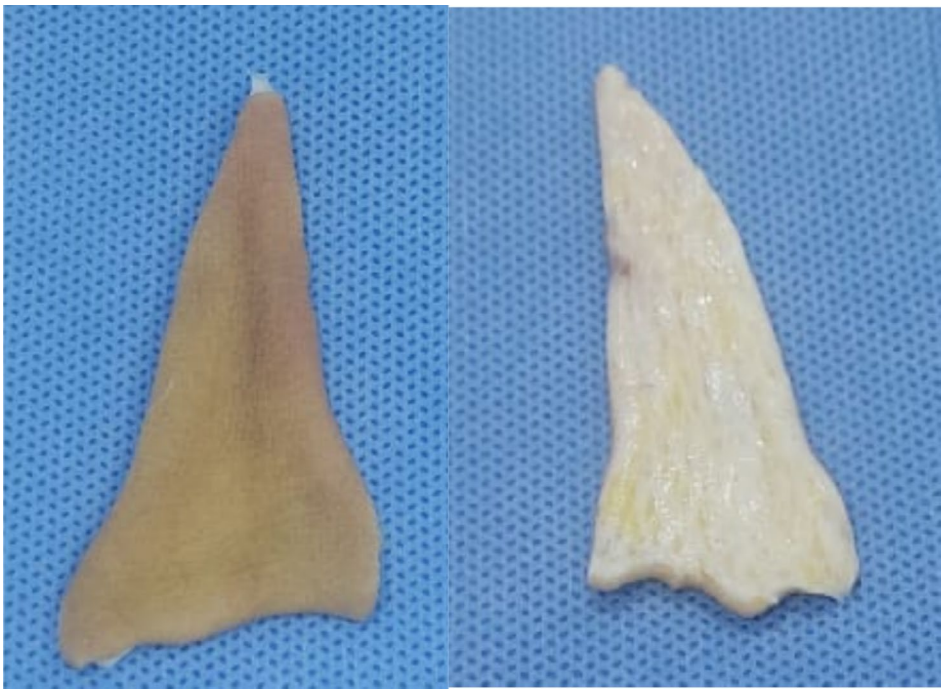

FIGURE 8 | Cryopreserved total skin allograft—epidermal side (left) and dermal side (right).

TABLE 1 | Demographic and surgical characteristics of the donor population.

Sex	Female: 245 Male: 3
Age	Mean: 41, 3 años Range: 17 a 73 años
Primary surgery	Abdominoplasty: 242 Reduction mammoplasty: 6

TABLE 2 | Distribution of donors and skin processing by year (2022–2024).

Year	Donors	Total area (cm^2)	Average area (cm^2)	*N*° graft sheets
2022	64	20.652	322.7	649
2023	124	36.020	290.4	936
2024	60	24.621	410.3	465
Total	248	81.293	327.8	2.050

TABLE 3 | Causes of tissue discard.

Cause of discard	2022	2023	2024	Total
Microbiology	1	8	1	10
Cold chain loss	21	11	6	38
Rejected sample	1	3	2	6
Risk factors in interview		4		4
Physical examination		1		1
Small flap		2		2
Bank logistics		2		2
Incomplete documents		4		4
Incomplete serology	4			4
Total	**27**	**31**	**9**	**67**

Note: Bold values indicate discard causes highlight logistical and infrastructure vulnerabilities rather than donor or biological limitations. Improving these areas will enhance tissue bank sustainability.

4.2 | Clinical Series

The clinical series included 10 patients (in 2 of whom two procedures were performed), aged between 2 months and 75 years. Diagnoses included diabetic foot (4 cases), contained laparostomy (2), complex lower limb wounds (2), recurrent scalp sarcoma (1), and melanoma (1). In all patients, initial take of the CTSA was observed. Around day 21 post-implantation, graft rejection was observed, characterised by a change in coloration and the gradual formation of a superficial necrotic eschar. Histological analysis of the removed CTSAs revealed foci of necrosis with a predominantly polymorphonuclear infiltrate. Upon removal of the eschar, vital tissue firmly adherent to the recipient bed was appreciable. Histology demonstrated an interface rich in fibroblasts and neovascularisation. This interface, or neodermis, was also visible in imaging studies; in magnetic resonance imaging, the CTSA showed a non-enhancing superficial component and a deep component that enhanced with contrast medium, resembling vascularised dermis. Definitive management included two approaches: (a) escharectomy with split-thickness autografting over the neodermis, or (b) spontaneous eschar lysis with skin regeneration. The detailed results of the clinical series are summarised in Table 4.

TABLE 4 | Clinical experience summary.

Patient	Age	Gender	Diagnosis	Evolution
1	68 years	Male	Diabetic foot. Transmetatarsal amputation	Surgical debridement/bone resection/ CTSA/scarectomy/split-thickness skin graft/graft loss/advanced wound healing/ complete healing and closure.
2	26 year	Male	Complex wound of the leg	Surgical debridement/CTSA/advanced wound healing/complete healing and closure.
3[a]	53 years	Female	Recurrent dermatofibrosarcoma of the scalp	Tumour resection/skull fenestration/ CTSA/advanced wound healing.
4	55 years	Male	Diabetic foot. Transmetatarsal amputation	surgical debridement/CTSA/scarectomy/ split- thickness skin graft/loss of follow-up
5	70 years	Male	Abdominal sepsis. Open abdomen	Complicated inguinal hernia/abdominal sepsis/multi-organ failure/contained laparostomy, CTSA/clinical improvement/ extubation/death due to pneumonia
6[a]	2 months	Male	Premature. Necrotizing enterocolitis. Contained laparostomy.	Premature 30 weeks/dysfunctionalisation of intestinal transit/evisceration (2 occasions)/contained laparostomy/CTSA/ para-ostomal hernia and inguinal hernia. Periostomal and inguinal hernioplasty.
7	60 years	Male	Diabetic foot	Surgical debridement/scarectomy/ CTSA/split- thickness skin graft/90% success/loss of follow- up
8	49 years	Male	Diabetic foot	Surgical debridement/scarectomy/ CTSA/loss of follow-up
9	57 años	Male	Skin stripping of the leg	Scarectomy/CTSA/split-thickness skin graft/100% success.
10[a]	3 months	Male	Premature. Necrotizing enterocolitis. Contained laparostomy.	30-week preterm infant. CTSA exchange. Contained abdominal wall with subsequent skin regeneration.
11[a]	53 años	Female	Recurrent dermatofibrosarcoma of the scalp	CTSA replacement in the central area. No autograft due to absence of neodermis in the central area (initial bone wax in that area). Skin regeneration.
12	75 años	Male	Cheek melanoma	Melanoma excision. Delayed post-biopsy reconstruction with local flap.

Abbreviation: CTSA, cryopreserved total skin allograft.
[a]Patient undergoing two interventions with cryopreserved total skin allograft.

5 | Discussion

The global shortage of tissues—particularly skin—remains a critical issue in many countries [9]. This study demonstrates that skin donation through the use of surgical waste from body contouring procedures represents a viable and sustainable alternative for the supply of skin allografts (SA). This model not only addresses the limited availability of cadaveric skin, but also introduces an approach that can be replicated in other settings, using residual surgical tissue as a source of allografts.

In the cadaveric donation model, increasing donation rates depend largely on cultural change—a slow and complex process often hindered by family refusal and public mistrust [14–16]. Even when cultural shifts do occur, they may take decades to translate into tangible results. In contrast, although body contouring surgeries yield smaller skin areas per donor, the increasing frequency of these procedures and the absence of donation refusal in our series suggest that the growth of this model relies more on the development of TGC. In this context, such centres correspond to high-volume plastic surgery clinics and hospitals, whose collaboration with tissue banks is essential [17].

This shift implies a transformation in the tissue bank management model—from consumption-based systems, typically associated with burn centres, to production-based systems, where tissue banks work directly with TGC to ensure a sustainable and efficient supply.

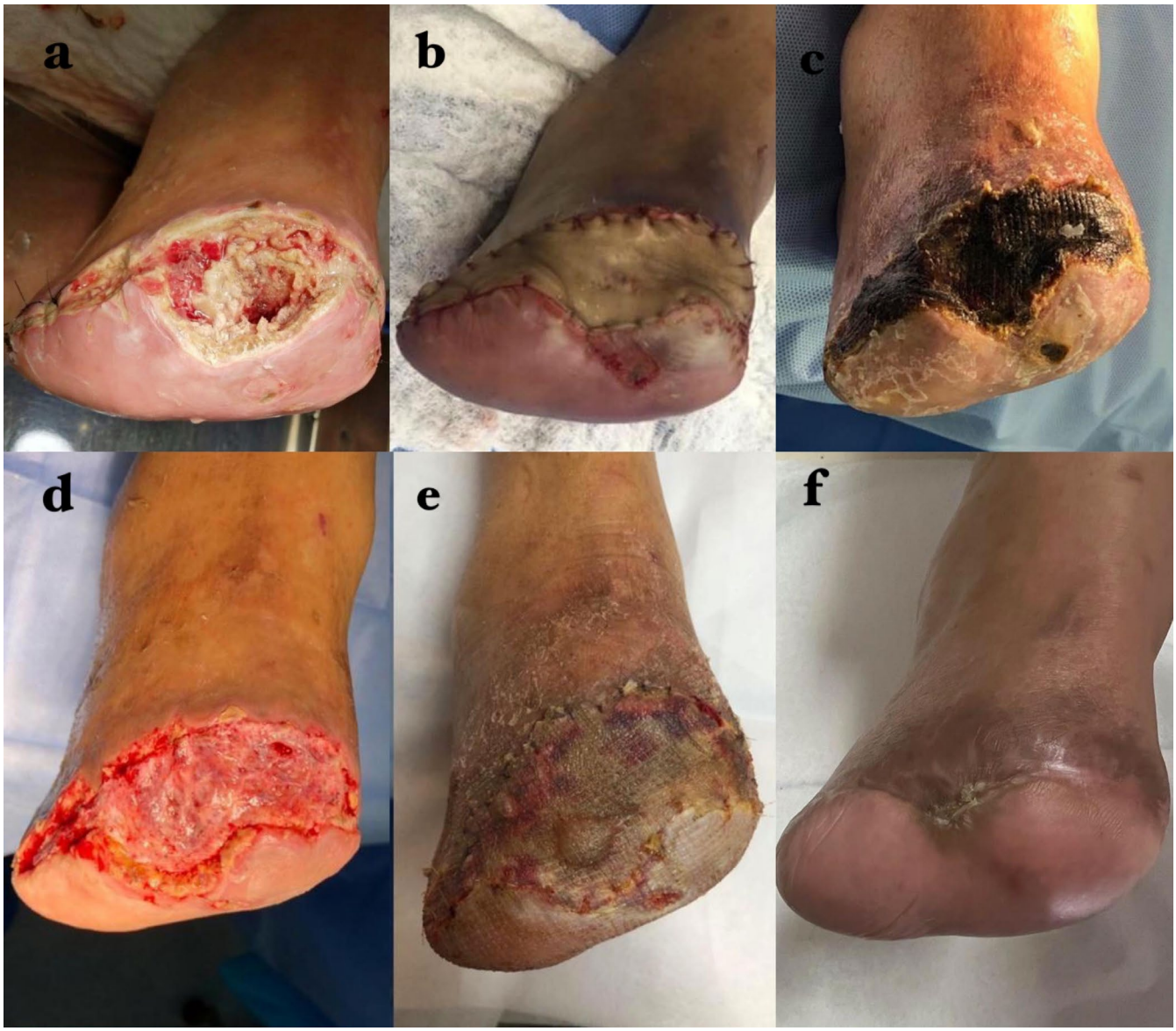

FIGURE 9 | Cryopreserved total skin allograft as intermediate coverage or bridging therapy. (a) Diabetic patient with a history of transmetatarsal amputation, presenting with stump compromise, cutaneous necrosis, superinfection, and bone exposure. (b) Surgical debridement is performed, followed by coverage with a cryopreserved total skin allograft. (c) Formation of a superficial necrotic eschar. (d) Superficial escharectomy reveals neodermis formation in the deeper layer. (e) Partial-thickness autograft is applied. (f) Outcome at 6 months [22].

In addition, in the living donor model, donors themselves play a key role by becoming ambassadors and advocates for the donation process. Their personal experiences and testimonies help build public trust, raise awareness, and reduce the cultural and emotional barriers that have historically limited the growth of tissue donation programmes. Unlike the cadaveric model, in which final authorisation lies with the family, in living donor skin donation, the decision is made directly by the patient. This is particularly relevant in countries with presumed consent laws, where family refusal continues to pose a major barrier [18, 19].

Exclusion criteria for skin donation are largely similar between cadaveric and living donors, as both aim to ensure the biosafety and quality of the graft [20, 21]. However, patients undergoing elective body contouring surgery typically present fewer contraindications than cadaveric donors [22]. Furthermore, many potential cadaveric donors spend prolonged periods in intensive care units, increasing their risk of colonisation by pathogenic microorganisms—an exclusion criterion for clinical use. In contrast, living donors are generally colonised only by commensal flora, resulting in lower contamination rates in processed grafts. In our experience, this was reflected in a 4% discard rate due to microbiological contamination, which is substantially lower than published rates for cadaveric donation, typically ranging from 20% to 30%. Although grafts with low bioburden of saprophytic or non-pathogenic organisms may be considered safe for clinical use, during this period the TSTB discarded all contaminated tissues—whether colonised by commensal or pathogenic organisms—without applying salvage or recycling protocols [23, 24].

Unfortunately, 15.3% of the CTSA processed at the TSTB was discarded due to cold storage system failure, which compromised the viability and safety of the tissue. This event was

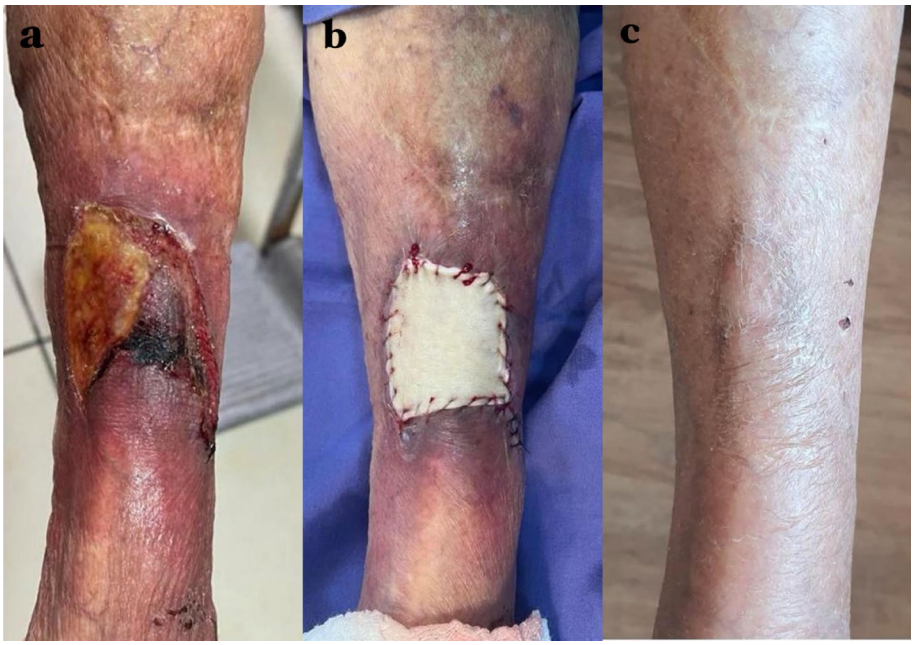

FIGURE 10 | Cryopreserved total skin allograft as a dermal regenerator. (a) 101-year-old patient with a traumatic leg wound of 3 weeks' evolution. (b) Surgical cleansing, debridement of devitalised tissue, and coverage with a cryopreserved total skin allograft. (c) Outcome after 3 months of evolution [22]. The patient shown is not part of the clinical series; case shown for illustrative purposes only.

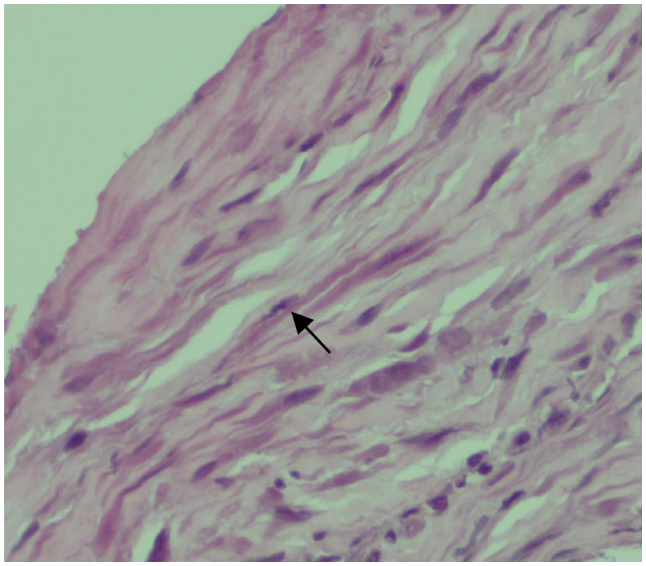

FIGURE 11 | Histological section of the recipient bed stained with haematoxylin and eosin (H&E), 40× magnification. Connective tissue is observed with the presence of fusiform fibroblasts (black arrow), characterised by elongated nuclei and scant cytoplasm, distributed within the extracellular matrix.

caused by a single, isolated power outage and a backup system malfunction that affected grafts processed in 2022, 2023, and 2024. Notably, despite Chile's extensive geography and the long distances between TGC, TSTB, and the hospitals and clinics where the grafts are applied, no cold chain failures occurred during transportation. In response to this incident, specific strategies are being implemented to prevent future losses, including strengthening emergency power systems, optimising cold storage protocols, and introducing real-time temperature monitoring.

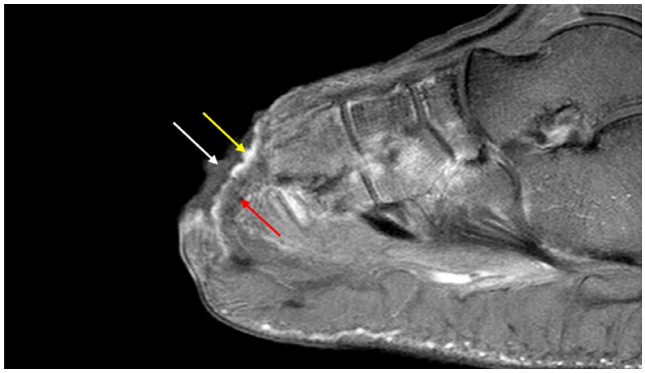

FIGURE 12 | Magnetic resonance images of the foot in the sagittal plane from a patient with diabetic foot and a history of transmetatarsal amputation, showing the CTSA with a superficial component that does not enhance with contrast (white arrow) and a deeper component that enhances with the contrast medium (yellow arrow), resembling vascularized dermis. Between the latter and the bone tissue, there is a low-signal area with mild enhancement (red arrow) [5].

From a processing perspective, manual defatting of the dermal-fat flap, rather than the conventional dermatome approach, preserves the entire dermis, resulting in full-thickness skin allografts rather than the split-thickness grafts typically obtained from cadaveric donors. Historically, both split- and full-thickness autografts evolved in parallel, with notable contributions from pioneers such as Jacques-Louis Reverdin, Leopold Ollier, Carl Thiersch, and Fedor Krause. Although full-thickness grafts were initially criticised, their benefits over split-thickness grafts, improved aesthetic outcomes, reduced scar contracture, and greater functional mobility, were later recognised [25].

The development of CTSA—characterised by (a) derivation from living donors, (b) complete preservation of the dermis,

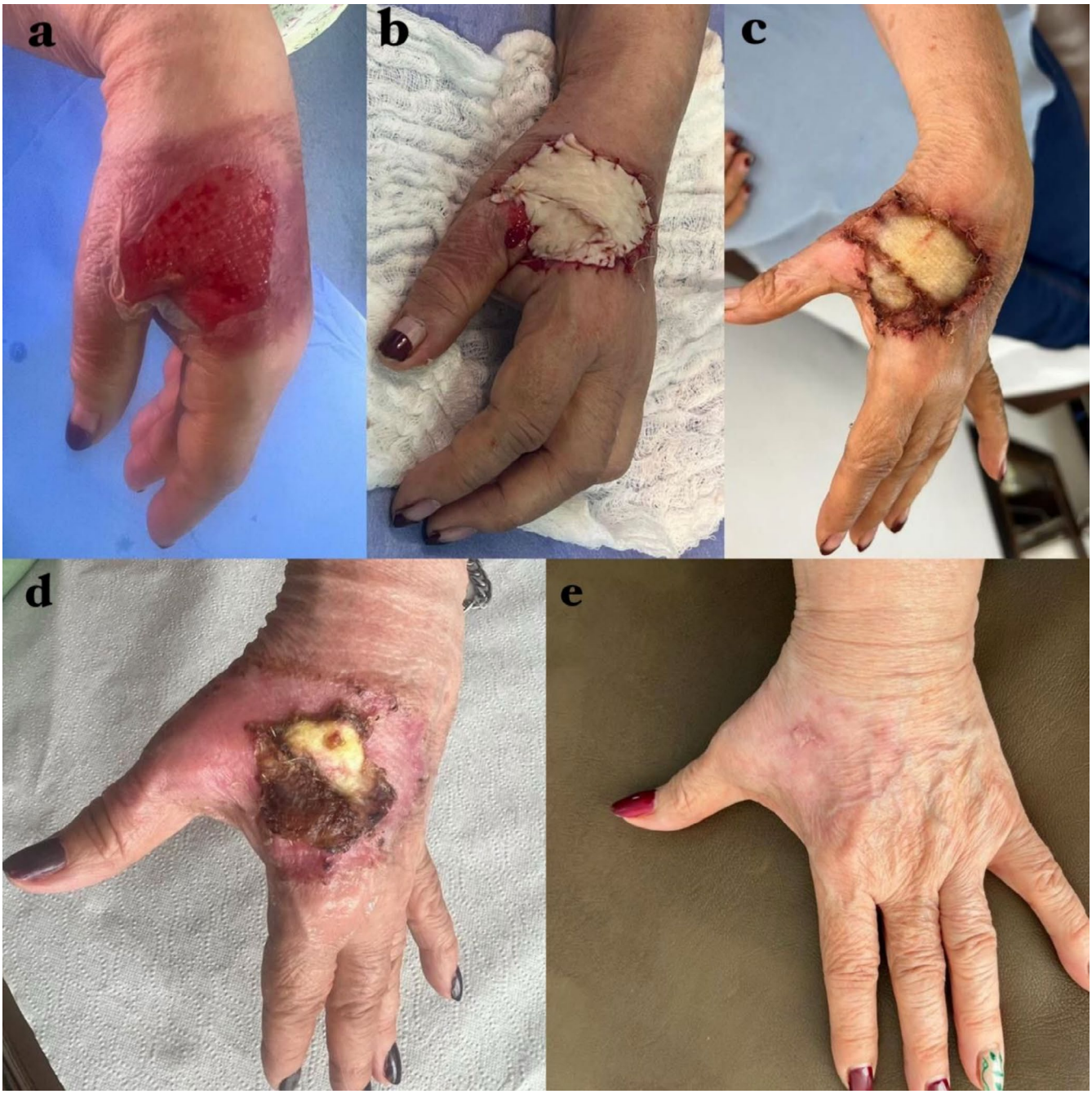

FIGURE 13 | Cryopreserved total skin allograft in burns of special areas. (a) Deep second-degree burn on the dorsum of the hand and base of the first and second fingers. (b) Coverage with a cryopreserved total skin allograft. (c) Initial graft take and marginal necrosis at 14 days. (d) Gradual detachment of superficial eschar (30 days). (e) Outcome at 50 days. The patient shown is not part of the clinical series; the case shown is for illustrative purposes only.

and (c) maintenance of tissue viability through cryopreservation—offers a novel therapeutic option for the management of complex wounds [26, 27]. Although defined as temporary coverage, in certain contexts these grafts may serve as intermediate or bridging coverage, allowing for dermal integration prior to autografting, or even as definitive coverage by functioning as a dermal regeneration scaffold (Figures 9 and 10). In such cases, their persistence is not due to immunologic tolerance, but rather their capacity to stimulate regenerative processes that support wound closure and dermal reconstruction. In this context, CTSA can be conceptually integrated within the tissue engineering triad: (a) cells, the active elements responsible for driving the biological processes required for repair and regeneration, including the potential future use of adipose-derived mesenchymal stem cells; (b) scaffolds, which provide the three-dimensional structural and biochemical framework necessary for cell growth, organisation, and proliferation; and (c) growth factors and signalling molecules, which regulate cell differentiation and function within the scaffold. Thus, the traditional medical view of skin allografts as temporary coverage may evolve toward a bioengineering perspective, in which these grafts are conceived as regenerative platforms capable

of inducing the formation of a functional neodermis [28–34]. Paradoxically, immune rejection—historically regarded as a negative event—can be clinically interpreted as a trigger or "initiator" of regenerative processes, by promoting the release of cellular mediators and remodelling the tissue microenvironment in a manner favourable to regeneration [35–37].

Our first clinical series provides direct evidence of this regenerative role. All patients demonstrated initial CTSA take, followed by graft rejection around day 21, with progressive formation of a superficial necrotic eschar. Histological analysis and MRI revealed a fibroblast-rich, vascularised neodermis beneath the eschar, firmly adherent to the recipient bed (Figures 11 and 12). Definitive management included either escharectomy with split-thickness autografting over the neodermis or spontaneous eschar lysis with complete skin regeneration. The SARS-CoV-2 pandemic interrupted follow-up in some cases, limiting long-term evaluation. Nevertheless, these findings support the concept of CTSA as a viable biological scaffold capable of guiding dermal regeneration in vivo [12].

The integration of viable dermal components, particularly fibroblasts and newly formed blood vessels, supports the formation of a neodermis, which is subsequently repopulated by recipient cells. While this mechanism is also seen in split-thickness allografts, the greater viable dermal thickness of CTSA provides a more robust biological scaffold [38]. Xenograft studies have shown that CTSA stimulates angiogenesis and type I collagen synthesis without inducing a significant fibrotic response [39]. Their primary indication is the coverage of complex wounds with exposed bone, cartilage, or tendons, or wounds with impaired healing. These grafts offer superior coverage in terms of thickness and elasticity, represent a low-cost alternative to commercial dermal matrices, and may be used in contaminated wound beds.

In patients with extensive burns—historically the main recipients of SA—advances in care have improved survival but often at the cost of functional and aesthetic sequelae. These outcomes are primarily attributed to the limited dermal contribution of autografts and to second-intention healing, which has prompted the development of dermal substitutes. Damour's aphorism captures this well: "If the epidermis ensures survival, the dermis ensures quality of life." While split-thickness allografts remain preferred for large surface areas due to lower metabolic demand and better take, certain anatomical regions require more advanced reconstructive strategies [40–43]. (Figure 13) Accordingly, CTSA may be particularly recommended for: (a) stable patients requiring coverage of irregular wound beds, fascia, or muscle, to enhance dermal integration and reduce sequelae; and (b) deep burns in critical or joint areas, where increased dermal thickness improves both functional and aesthetic outcomes.

Finally, although the skin surface obtained from body contouring procedures is significantly smaller than that obtained from cadaveric donors—which could affect the economic efficiency of the model—the added clinical value of CTSA, derived from its dermal regenerative potential, supports its cost-effectiveness compared to significantly more expensive commercial dermal matrices. From this perspective, CTSA represent an accessible and sustainable therapeutic alternative, particularly in low- and middle-income countries, for the treatment of localised complex wounds, chronic ulcers, and injuries with exposed critical structures [44–49].

6 | Conclusions

Implementing a skin banking model based exclusively on living donors undergoing body contouring procedures offers a viable, sustainable, and replicable strategy to address the global shortage of cadaveric skin, particularly in settings with low donation rates and limited access to advanced wound care. Beyond serving as temporary coverage, CTSA preserved in their full dermal thickness act as biological scaffolds capable of guiding in vivo dermal regeneration, as demonstrated by the consistent formation of fibroblast-rich, vascularised neodermis in our series. This dual function—coverage and regeneration—reinforces their clinical value, especially for complex wounds with exposed critical structures. The model's high donor acceptance, low contamination rates, and logistical resilience support its integration into high-volume plastic surgery centres worldwide. Future multicentre prospective studies should define optimal clinical indications, healing timelines, and long-term outcomes, while exploring the synergistic combination of CTSA with cells and signalling cues to maximise their regenerative potential.

Disclosure

Marcelo Fonseca is the inventor of a patent related to the cryopreserved total skin allografts described in this article. The patent was granted in Japan on May 20, 2025, and is under review in other countries. No royalties or financial compensation have been received. The authors declare no commercial bias.

Ethics Statement

All procedures and protocols were performed under the supervision of the National Coordination of Organs and Tissues Transplantation of Health Ministry of Chile, with the authorization of the regional Ministry of Health from Tarapacá, and with the consent of the Ethics Committee of the Tarapacá Health Service (ACTA SEC SSI Número 3/2022).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are stored in the *Sistema Integrado de Donación de Órganos y Trasplante (SIDOT)*, a national regulatory system that manages organ and tissue donation in Chile. Due to legal and ethical restrictions regarding patient and donor confidentiality, these data are not publicly available. Access to the data can be obtained through formal request and authorization from the Chilean National Transplant Coordination Office, in accordance with national regulations.

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