Received: 1 February 2023 | Revised: 2 June 2023 | Accepted: 5 June 2023

DOI: 10.1002/hsr2.1353

ORIGINAL RESEARCH

Health Science Reports Open Access WILEY

Minced skin grafts for chronic wounds compared to conventional mesh grafts

Débora C. Sanches-Pinto[1] | Elof Eriksson[2] | David S. Gomez[1] | Maria P. T. Nunes[3] | Rolf Gemperli[1] | Francisco G. Soriano[4]

[1]Divisão de Cirurgia Plástica e Queimaduras. Clinicas Hospital - School of Medicine, University of São Paulo, São Paulo, Brazil

[2]Harvard Medical School, Boston, Massachusetts, USA

[3]Department of Internal Medicine, School of Medicine, University of São Paulo, São Paulo, Brazil

[4]School of Medicine, University of São Paulo, São Paulo, Brazil

Correspondence

Débora C. Sanches-Pinto, Clinicas Hospital - School of Medicine, University of São Paulo, Rua Bertioga, 132/72, São Paulo 04141-100, Brazil.
Email: deborasanches29@uol.com.br

Abstract

Background and Aims: Skin grafting is the single most effective method to close a chronic wound. The current standard of care is to use meshed split thickness skin grafts. This entails the use of surgical instruments that need to be autoclaved and to have a power source, which usually requires an OR facility. The minced skin technique uses single use, presterilized instruments and the procedure can be done under local anesthesia, by a wound care practitioner, in a wound clinic, a physician's office or even at the bedside. The current study was designed to determine if the results from micrografting were non inferior to conventional mesh grafting.

Methods: In a prospective non inferiority study, 26 chronic ulcers were treated with micrografting (MSG) and 24 with conventional mesh grafts 1:3 (control group-CG) in a total of 21 patients, 10 male and 11 female. The donor site areas in the MSG group were predetermined to 2.5 × 5 cm and the mesh grafts expansion was set at 1:3.

Results: In the first weeks postoperatively, micrograft healing initially lagged behind the conventional mesh grafts but at 60 days after grafting, all MSG wounds were healed. The MSG wounds had better pigmentation, less itching, and less scarring. The micrografting procedure was easy to learn and expeditious to perform. The MSG mean expansion was 9.1 compared to three times (CG).

Conclusion: The MSG procedure is not inferior to conventional mesh grafting, requires smaller donor sites, and can be done with single use instruments, under local anesthesia, with early discharge.

KEYWORDS

burns, chronic wounds, micrografts, skin graft expansion, skin grafts, wound care

1 | INTRODUCTION

Chronic wounds are those present for more than 4 weeks[1,2] failing to produce anatomical and functional skin integrity. Their etiologies include diabetic, arterial, venous, traumatic, infectious and burns.[2,3]

Chronic wounds are predominantly a condition of individuals who are old, have a chronic illness or are treated with certain medications. They are gradually becoming more prevalent.[1]

It is very important to understand how expensive it is to treat chronic wounds to be open to new, more versatile technologies that require less

resources and reduce costs. This must be considered not only in a low-income country such as ours (Brazil) but also in high income countries.

In developed countries the prevalence of chronic non healing wounds is 1%–2% of the general population,[4,5] similar to the prevalence of heart failure.[6] The morbidity to the patients and associated costs of chronic wounds, have received less attention from a public policy stand point in the United States and also in Brazil, perhaps because no single medical specialty has full responsibility for their treatment.

Despite therapeutic advances, many chronic wounds persist and recurrence is high. In Brazil, Social Security data reveals that chronic venous disease is ranked 14th as a cause of temporary leave from work and occupies the 32nd position on the list of permanent disabilities. The Brazilian Institute of Geography and Statistics (IBGE) established that prevention measures for recurrent venous ulcer treatment could save nearly $1 billion in 5 years.[7–9]

For the success of grafting chronic wounds, the wound bed preparation is extremely important. A precise diagnosis is followed by medical optimization of comorbidities, nutritional enhancement, maximizing perfusion, reducing bacterial counts, controlling biofilm, and removing nonviable tissue.[10–13]

Debridement remains a cornerstone of good wound bed preparation because it removes barriers to healing (debris, necrosis, slough, bacteria, biofilm), reduces the risk of infection, improves the microcirculation, normalizes wound biochemistry, including metalloproteinase regulation and stimulates the wound edges.[10–13]

We may also need special equipment such as a hydro-surgery system or negative-pressure wound therapy (NPWT), besides special dressings to prepare the wound bed for grafting.[10–13]

The timing of surgical interventions must be precise and combined with other therapeutic measures as needed.[10–13]

The gold standard method to close non healing wounds is split thickness skin grafting. The grafts are often meshed for expansion, malleability and drainage. Meek published a method for skin expansion in 1958[14] where a split thickness skin graft was cut into 4 × 4 mm squares which Meek called micrografts and placed on an expandable carrier membrane. The membrane and the skin particles were then expanded and placed on the wound with the dermal side down. This allowed an expansion of the original skin graft of up to 10 times. The technique was cumbersome and required expensive equipment. As a result the Meek Technique never gained widespread popularity.

In 1964 Tanner et al.[15] described a technique for meshing and expanding split thickness skin grafts, making it much less laborious and faster. Tanner developed the Tanner-Vandeput dermatome (today called a mesher), creating the mesh graft.

The skin is placed on a plastic carrier allowing it to pass between the mesher cylinders, which have numerous short cutting edges wich create cuts to give the graft a fishnet-like structure. The graft can then be expanded (stretched) three to nine times, in theory, but expansions over three times will not provide a very useful graft.[15,16]

Eriksson and colleagues developed a new technique for skin graft expansion by cutting the graft in perpendicular directions, creating 0.8 × 0.8 mm particles (micrografts). The split thickness skin graft is minced with a device containing parallel cutting discs spaced 0.8 mm apart (Applied Tissue Technologies LLC). It has been shown experimentally[17,18] and clinically[19,20] that in a moist environment, orientation of the skin particles is unimportant. With 0.8 × 0.8 mm skin particles (micrografts) an expansion of 100 times has been achieved experimentally. In this porcine model the transplantation of micrografts in a 1:100 expansion ratio resulted in complete epithelialization of both healthy and diabetic pigs within 14 days. In comparison, nontransplanted wounds in pigs showed 62%reepithelialization.[18]

Grafts as small as 0.3 × 0.3 mm, called pixel grafts, when transplanted to wounds demonstrated a faster reepithelialization, decreased wound contraction, and increased mechanical stability compared to nontransplanted wounds. The reepithelialization was significantly higher on Day 6 after wounding compared to micrografted wounds.[21] Pixel grafts, have in experimental studies achieved till 500 times expansion[22] The primary aim of this study was to demonstrate the noninferiority of the MSG in the grafting and healing of chronic full-thickness wounds, compared to the 1:3 mesh graft. Secondary aims were to calculate the mean expansion ratio, the degree of difficulty to perform the procedure, the degree of pain in the recipient area, the prevalence of itching and the final cosmetic appearance.

2 | METHODS

This was a prospective noninferiority study, with a series of 50 full-thickness chronic skin ulcers, 26 treated with MSG (Study Group MSGG) and 24 treated with 1:3 mesh grafts (Control Group-CG) according to the sample size calculation (ANOVA repeated measurements, within and between interactions).

We included 26 ulcers (14 patients) in the MSGG and 24 ulcers (7 patients) in CG. The total number of patients was 21, 11 female, and 10 male.

All ulcers were classified as chronic,[1] ranging from 2 and a half months to 6 years of presence.

Their etiologies were: chronic 3rd degree burn wounds, post-infectious ulcers, venous ulcers, traumatic ulcers and diabetic ulcers, of variable sizes.

The study method, which expands the skin up to 100 times in pig studies[18] led us to choose, for comparison, the method that, in Brazil is the standard of care and has the greatest expansion, which is the mesh graft expanded three times. Our public hospital, as well as all other hospitals in Brazil, have no access to the Meek's modified method, which provides 10 times expansion.

We have not considered any combination methods such as the “sandwich” technique, associating mesh graft 1:6 or 1:9 with cadaveric skin or others. The minced skin graft method provides greater expansion and therefore should be compared to the standard expansion currently available in our hospital.

The study protocol was submitted to “Plataforma Brasil” which is a national unified database of research records involving human subjects for the entire CEP/CONEP system (National Committee of Ethics in Research in Human Beings). It allows studies to be monitored in their different stages, from their submission to final approval by CEP and

CONEP, when necessary, even enabling monitoring of the field phase, sending progress reports and final research reports. We got the approval of the Ethics committee (CAAE 05882918.9.0000068–4.991.773/USP-HCFMUSP) before starting this study. The study was conducted in accordance with World Medical Association Declaration of Helsinki ethical guidelines. There is no funding for this study besides what was provided by the main author.

Consecutive patients who met the inclusion criteria listed below were provided informed consent and asked to sign the Free Informed Consent Form (ICF) for participation in the research.

Inclusion criteria: patients over 18-year-old, both sexes, able to understand and sign the informed consent after a careful explanation of all aspects of the study; clinically optimally treated for their comorbidities, if any, without clinical contraindications to the surgical procedures; patients with full-thickness chronic wounds; absence of invasive infection, and with good wound bed preparation.

Exclusion criteria: alcohol or other substance abuse; psychiatric disorders; inmates; patients on systemic corticosteroids; pregnant or lactating patients; patients already participating in other studies; patients with deep structure exposure that could not be covered by skin grafts, such as bones, vessels, tendons and cartilage, or wounds without acceptable local conditions for grafting.

After adequate wound bed preparation, debridement and confirmation of negative cultures, inclusion in the study protocol occurred, both for the MSGG group and for the CG. No patient took part in both groups and there were no subsets of patients.

Once included in the study, 26 areas (full-thickness chronic wounds) were grafted by the minced skin graft method using the Xpansion® Mincer KIT (sterile and has a disposable manual dermatome as well as all the other components necessary for the surgical part of the procedure so an autoclave is therefore not needed) and 24 areas were grafted with a conventional mesh graft expanded 1:3 (three times). Both groups were followed for 60 days after the skin grafts were performed, including the following parameters: percent of area epithelialized, degree of pain before and after skin grafting, at PO7 and PO60; degree of difficulty for the surgeon in performing the minced skin graft procedure and subsequent dressings according to a scale 1–5 (1 very easy, 2 easy, 3 average, 4 difficult, 5 very difficult). This was evaluated by the surgeon, recipient area final cosmetic appearance; presence or absence of itching; degree of expansion obtained with the use of minced skin grafts compared to the 1:3 mesh graft.

2.1 | Study group –MSGG

All the patients were completely debrided before entering the study. After that 26 areas were grafted with the MSG and 24 areas were grafted with a 1:3 mesh graft (CG). Both groups were followed for 60 days. The donor site was the upper thigh, with variable sizes in the CG and a fixed size in the MSGG of 2.5 cm × 5 cm (12.5 cm^2), first marked with an ink pen. The width of the graft (2.5 cm) is determined by the width of the dermatome blade, which is guarded on both sides. We were very careful to make each graft precisely 5.0 cm long.

The mincer itself has a plastic handle and 24 parallel rotating cutting disks 0.8 mm apart. The kit (completely sterile and disposable) also contains a surgical forceps, spatula, 10 mL syringe, plastic cutting plate, and manual dermatome precalibrated to 0.012 inches (0.3 mm).

The next picture shows the mincer with 24 parallel cutting discs that simultaneously hold and cut the skin. (Figure 1A).

The donor site was marked with a ruler, with fixed measurements of 2.5 ×5.0 cm (12.5 cm^2), and after antisepsis with 2% chlorhexidine, it received an injection of local anesthetic (0.5% xylocaine with epinephrine in a dilution of 1:200,000).

The skin graft was excised with the manual dermatome. The graft was then placed on the plastic plate and cut in perpendicular directions with the mincer. This process resulted in micrografts measuring 0.8 × 0.8 mm that were evenly mixed into the hydrogel (Normlgel® manufactured by Advanced Medical Solutions, UK. The precise composition of the Normlgel is not publicly available, but it contains sodium chloride, water and xanthan gum) before application with a spatula over the recipient site. (Figure 1B).

We spread the micrografts as evenly as possible. This is better seen in a magnified picture (Figure 1C).

A sterile multiperforated silicone interface dressing (Mepitel One®-Mölnlycke) (Figure 1D) was applied over the grafted area and a thicker hydrogel layer (Normlgel®) (Figure 1E) was put over it to keep the grafts in a moist environment.[23]

Since Winter's report in 1962[23] we know that a moist wound environment has several benefits that lead to faster and better quality of healing. This has been confirmed and detailed in a number of publications.[24]

A secondary absorbent foam dressing (Mepilex® Mölnlycke) was utilized (Figure 1F). with an outer layer of protective gauze and a compression bandage. For the CG, the standard of care used was an interface, perforated, nonadherent dressing covered by a tie over gauze dressing. Over this a compression bandage was used.

The primary interface dressing was kept in place for 14 days and then replaced. On the third day (PO3), the secondary dressing was removed, and an additional layer of sterile amorphous hydrogel was applied over the multiperforated silicone interface dressing and the secondary dressing was replaced.

On PO14, PO21, PO30, and PO60 both the interface dressing and the secondary dressings were replaced if needed (when the wound was not completely healed).

At each dressing change, photos of the wound areas were obtained with a Silhouette v3 camera (Aranz Medical, New Zealand)—and the SilhouetteConnect® software was used to measure the nonepithelialized area, to be further evaluated in thestatistical analysis (Figure 2).

The patients were asked to assess their degree of pain in the recipient area using the analogue pain scale in the preoperative period and on PO1, PO7—and at the end of the study (PO60).

At the end of the study, an evaluation of the grafted areas was performed, regarding vascularization, pigmentation, flexibility and scar height, using the Vancouver Scar Scale[25] to assess the cosmetic and functional result. The Vancouver Scar Scale is the standard scale used for burns and wounds in our hospital.

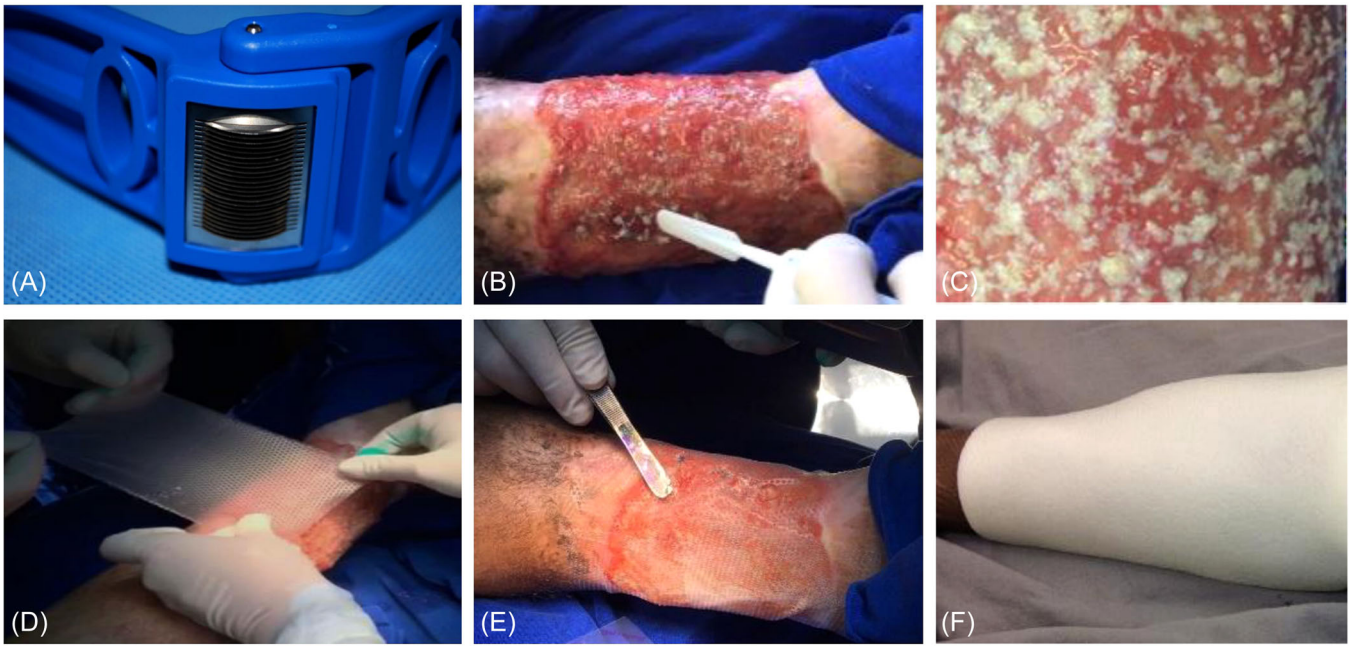

FIGURE 1 (A) The head of the mincer with parallel cutting disks. (B) The minced skin grafts being applied over the recipient area with the spatula. (C) The minced skin grafts applied over the wound, magnified ×5. (D) Initial postoperative dressing and subsequent dressings: primary dressing: silicone multiperforated interface dressing (Mepitel One®). (E) extra hydrogel layer (Normlgel®). (F) secondary absorptive silicone foam dressing (Mepilex®).

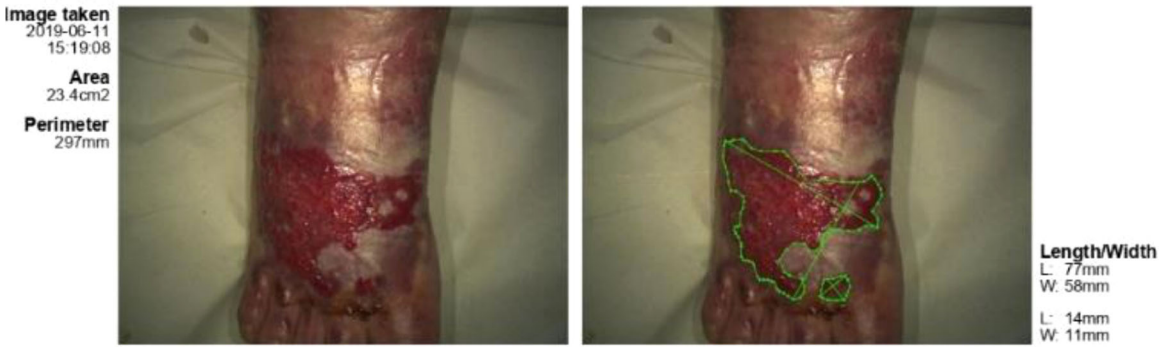

FIGURE 2 Example of the use of SilhouetteConnect® software to measure the wound area.

Numbers were assigned to each assessment by the surgeon, to allow further statistical evaluation.

At the end of the study, on PO60, we asked the patients about the presence of itching, their subjective opinion about the appearance of the grafted area, and presence of local hyper or hyposensitivity.

2.2 | CG

All grafts were obtained using the Zimmer® dermatome, set at 0.012 inches (0.3 mm) of graft thickness. The graft expansion was 1:3. A standardized dressing protocol (rayon interface dressing, gauze and compressive bandage) was utilized. Pictures were taken at every dressing change and measurements were done. Postoperative dressings changes were performed weekly until the end of the study, or until completely epithelialized following the dressing protocol with rayon gauze, metro gauze, and crepe bandage.

At the end of the study (PO60), the same questions that were asked in the MSGG group were posed and the Vancouver Scar Scale was applied.

All data obtained from both groups were compiled in an Excel® spreadsheet for statistical noninferiority statistical analysis.

2.3 | Statistical analysis

To study the distribution of qualitative variables according to the MGF and CG groups, the χ^2 test or Fisher's exact test was used when

necessary. The Mann–Whitney (MW) test was used to compare two independent groups in the case of quantitative variables. To analyze the evolution of lesions towards re-epithelialization over time and by groups, the repeated measures ANOVA test was used and, to analyze the evolution of pain, a nonparametric repeated measures ANOVA was used. All tests considered a bidirectional α of 0.05 and a confidence interval (CI) of 95% and were performed with the computational support of software R (https://www.r-project.org/), IBM SPSS 25 (Statistical Package for the Social Sciences) and Excel 2016® (Microsoft Office).

Through this study, we wanted to find out if it was possible to perform the skin grafting in a simplified way and with a noninferior result when compared to the conventional surgical treatment established for the past 60 years.

The data that support the findings of this study are available on request from the corresponding author.

3 | RESULTS

We evaluated 50 ulcers in 21 patients. There were 52.4% (11) females and 47.6% (10) males. The mean age of the group was 43.1 years (±17.8 years).

Their etiologies were: 3rd degree burn (64.0%), postinfectious ulcers (18.0%), venous ulcers (10.0%), traumatic ulcers (4.0%), and diabetic ulcers (4.0%).

The MSGG and CG groups were similar in age (Table 1).

An ANOVA model of repeated nonparametric measurements was developed to study the temporal variation in pain between the two groups. The CG started with a higher pain score with Relative Treatment Effect (ERT) = 0.90. evolved to an intermediate level in PO1 and PO7. with ERT = 0.54 and. after 60 days reaching a low level of pain with ERT = 0.31. The MSG group presented lower initial pain level with ERT = 0.60. falling to 0.47 and 0.32 in PO1 and PO7. and ending with ERT = 0.30 on day 60. The analysis indicates that there was group*time interaction with $p < 0.001$ (Figure 3).

The patients in the control group had a higher degree of wound pain preoperatively (PO0), and in the early postoperative period, and these patients with larger donor sites had more pain. It was also observed that on PO7, when changing the dressing, the CG still had a higher degree of pain than the MSGG. At the end of the study, at PO60 both groups had an equal amount of pain.

We observed a higher frequency of thinner scars and normesthesia in the MSGG (96.2% and 100%) versus CG (0.0% and 0.0%) with statistical significance ($p < 0.001$). Patients in the CG group described hyperesthesia (100%) also with statistical significance ($p < 0.001$). Itching was not observed in the MSGG. while it was present in 66.7% in the CG ($p < 0.001$) (Table 2).

The patients in the MSGG group considered the scars thinner ($p < 0.001$). Patients in the CG group described hyperesthesia ($p < 0.001$). According to the surgeon who operated on all the patients the difficulty level to perform the MSGG procedure, was considered easy and the subsequent dressings changes were considered very easy.

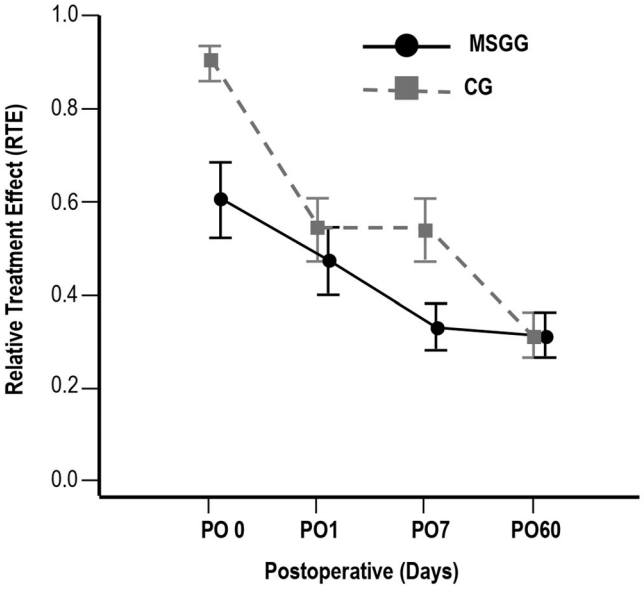

FIGURE 3 ANOVA repeated measures model to evaluate the postoperative development of pain between MSGG and control group.

TABLE 1 Age and area of chronic ulcers by groups, including mean, standard deviation, median, interquartile range (P25-P75), and descriptive level.

	Mean (±sd)	MSGG ($n = 26$) Median (iqr)	(Minimum–maximum)	Mean (±sd)	CG ($n = 24$) Median (iqr)	(Minimum–maximum)	p Value*
Age (years)	39 (±18)	38 (18–57)	(18–66)	41 (±18)	32 (29–57)	(19–80)	0.755*
Preoperative Area (cm^2)	61,2 (±70)	31,8 (11–95.6)	(1–256.6)	98,5 (±126, 9)	55,3 (37.5–112.7)	(7.6–600)	0.097*
Female		41.1%			57.1%		0.562**

Abbreviations: CG, control group; IQR, interquartile range; MSGG, Minced Skin Graft Group; SD, standard deviation.

*p Value based on Mann–Whitney U test; **p Value based on Fischer's exact test.

TABLE 2 Subjective parameters of chronic ulcers according to groups by area including absolute relative frequency, 95% confidence interval, and descriptive level on Day 60 (PO60—Final day of the study).

	MSGG		CG		
	n	% (95% CI)	*n*	% (95% CI)	*p* Value*
Height					
Thick	1	3.8% (0.4%–16.6%)	24	100.00%	<0.001
Thin	25	96.2% (83.4%–99.6%)	0	0.00%	
Sensation					
Hyperesthesia	0	0.0%	24	100.00%	<0.001
Normesthesia	26	100.0%	0	0.00%	
Itching					
No	26	100.0%	8	33.3% (17.2%–53.2%)	<0.001
Yes	0	0.0%	16	66.7% (46.8%–82.8%)	

The patients in the MSGG group considered the scars thinner ($p < 0.001$). Patients in the CG group described hyperesthesia ($p < 0.001$) (Figures 4 and 5).
*p Value based on fischer's exact test.

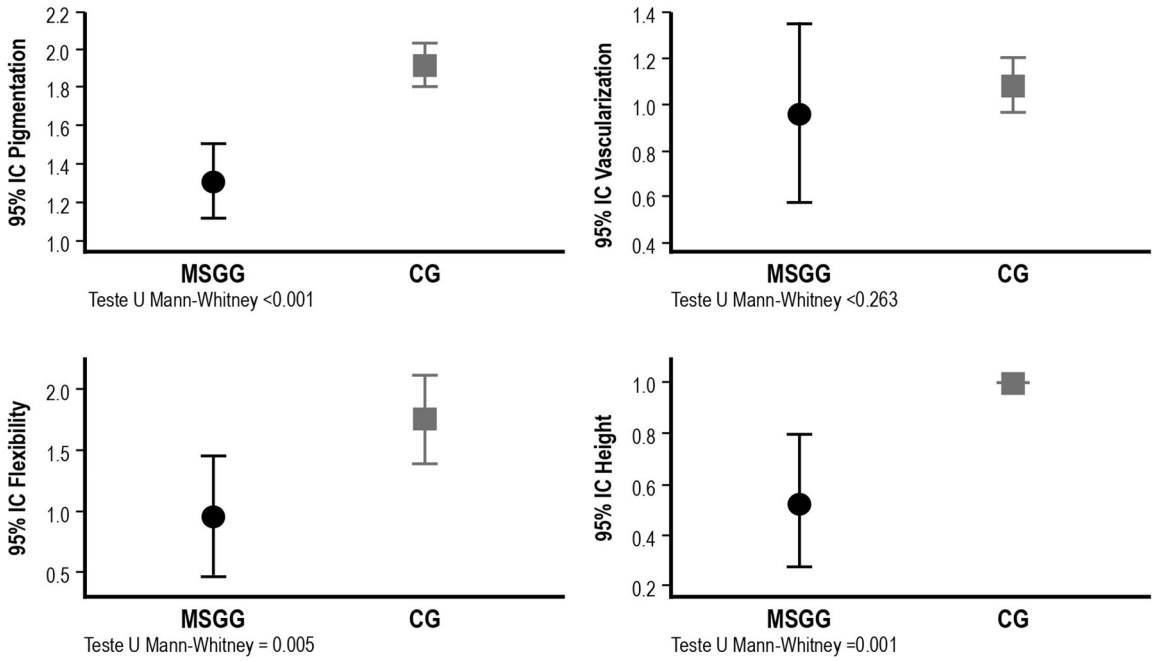

FIGURE 4 Average of the Vancouver Scale by groups (pigmentation, vascularization, flexibility and scar height).

Using the Vancouver Scar Scale, the scores of flexibility, pigmentation and scar height were significantly better in the study group ($p < 0.05$) and vascularization was not statistically different between the two groups) (Figures 4 and 5).

Comparing the median of percentages of epithelialization in the postoperative period showed on PO7 50.4% (MSGG) versus 71% (CG); PO14 58.0% (MSGG) versus 83.5% (CG). After that, the groups converged, with similar values at end of the study (PO60) with 100% (MSGG) versus 97.2% (CG) (Figure 6).

Figures 7 and 8 show the MSGG epithelization on different postoperative days and the final result similar to sheet grafts.

The MSGG mean expansion of was 9.1 times compared to the three times expansion in the CG. The MSGG has a predetermined donor site area in 12.5 cm^2 and the CG group had a uniform expansion of 1:3. The total MSGG recipient area was 1590.7 cm^2 and the total donor site area was 175 cm^2. The total CG recipient area was 2363.7 cm^2 and the total donor site area was 787.9 cm^2. In the MSGG we achieved an average expansion of 9.1 times, different from the CG with a three times expansion. A few patients had more than one wound grafted from the same donor site. Figure 9 shows the final results.

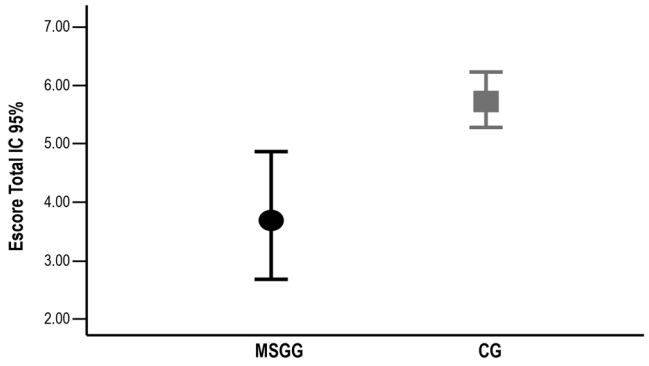

FIGURE 5 Average total score (sum of all points) by Vancouver Scale State what is better.

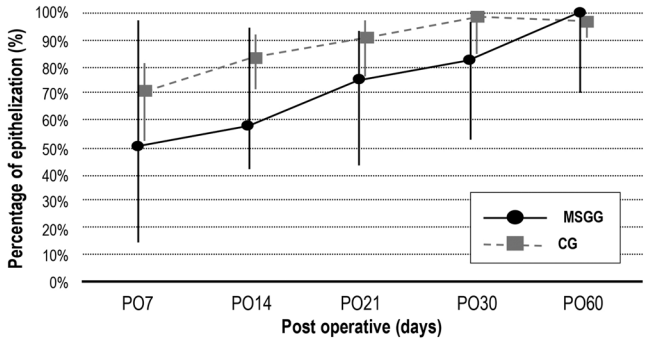

FIGURE 6 Median and interquartile range, nonparametric ANOVA model to evaluate the postoperative development of percentage of epithelialization between of MSGG and control group. Percentage of epithelialization at PO30 and PO60 are greater than PO7 ($p = 0.038$ and $p < 0.001$, respectively).

4 | DISCUSSION

The current study shows that micrografting is not only clinically feasible but is also provides healing results similar to sheet grafting. The micrografts were expanded three times more; nine versus three times; resulting in smaller donor sites. The micrografts caused less pain and itching, less pigment changes and less scarring. The single use instruments enable any wound care practitioner to do skin grafting in the wound clinic, the office or at the bedside under local anesthesia.

Reverdin introduced pinch grafts; which have some resemblance of micrografts; in 1861.[26] Meekconceptualized the use of micrografts in 1958[14] Meek's micrografts had to be placed with the dermal side down. This together with the cost and cumbersome use of his device limited the acceptance of his technique. The micrografting method described here eliminates these downsides.

Svensjö et al.[17] working in Eriksson's laboratory at Harvard Medical School, published the first study with the current technique, demonstrating that in a moist environment, orientation of the micrografts, dermal side up or down, was unimportant. Zuhaily et al.[27] then further studied the importance of a moist healing environment by placing mesh grafts either with the dermal side up or down with similar healing results. Hackl et al.[18] expanded micrografts (0.8 × 0.8 × 0.3 mm) 100 times and found 100% healing within 2 weeks in both healthy and diabetic pigs.

Sighn et al.[21] used smaller micrografts (0.3 × 0.3 × 0.3 mm), called pixel grafts. Nuutila has experimentally expanded the pixel grafts till 500 times with complete healing in 30 days, in pigs[22]

Clinically, this technique of transplantation has been validated by Hamnerius et al.[19] Danks and lairet[20] and others. It has the potential to be useful in very large burns with small skin donor sites because of offering a greater degree of expansion than other surgical techniques. The fact that the skin graft can be expeditiously expanded in the OR with disposable instruments makes it more attractive than various culturing and cell separation techniques.[28] In smaller wounds, the simplicity of this technique in combination with enabling the practitioner and facility to perform skin grafting under local anesthesia, adds a new dimension to skin grafting of small and medium sized wounds.

We know that no other method can provide this degree of expansion, except for the Meek method that our public hospitals in Brazil cannot afford. Because of that we compared the minced skin graft to mesh graft 1:3 which is the most common method we have in our hospital in São Paulo-Brazil. Though the mesh grafts starts with an advantage in initial area covered (at grafting in the mesh graft group, 33% of the wound is already covered by epidermis compared to 11% in the minced skin group) we wanted to see if the minced skin graft method would achieve wound closure by Day 60 (PO60), at the end of the study.

In conclusion, our study showed that minced skin grafts (MSG) in chronic wounds are no less effective than the traditional 1:3 mesh grafting method (CG), resulting in the total closure of all the wounds by the end of the study. The degree of pain was similar in both groups. The MSG procedure and dressing changes were easy and faster, compared to the CG. The MSG presented a much better cosmetic result because they were similar to sheet grafts. The MSG group did not have postoperative pruritus, unlike 2/3 of CG patients. The mean expansion of the MSG was 9.1 times, compared to the three times of the CG.

We consider the MSG method very promising, not only because it is easier and faster than other methods, presents a mean expansion of 9.1 times and also can be done on an outpatient basis leading to a good cost–benefit ratio, which is very important globally and particularly in low income countries.

4.1 | Study limitations

This study was prospective but not randomized. The procedures were randomly distributed according to the availability of material and especially the operating room and anesthetic team, as the mesh graft requires general anesthesia or anesthetic block whereas the micrografting was usually done under local anesthesia. Studies in low-income countries such as Brazil have all these limitations. Larger

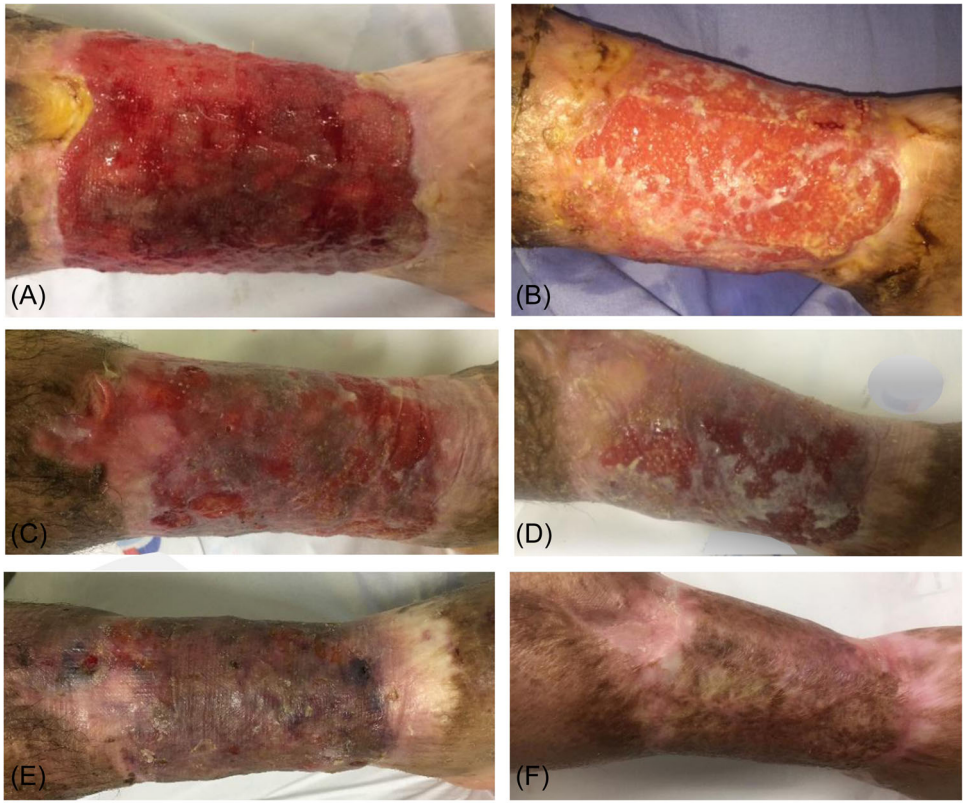

FIGURE 7 Circular Lower Leg Venous Ulcer with 180 cm^2 initial wound size. (A) Preoperative appearance. (B) PO7: The epithelial islands are starting to converge. (C and D) PO 21 and PO30: Show progression of healing. (E) PO60: Shows complete healing. (F) completed healed area similar to a sheet graft.

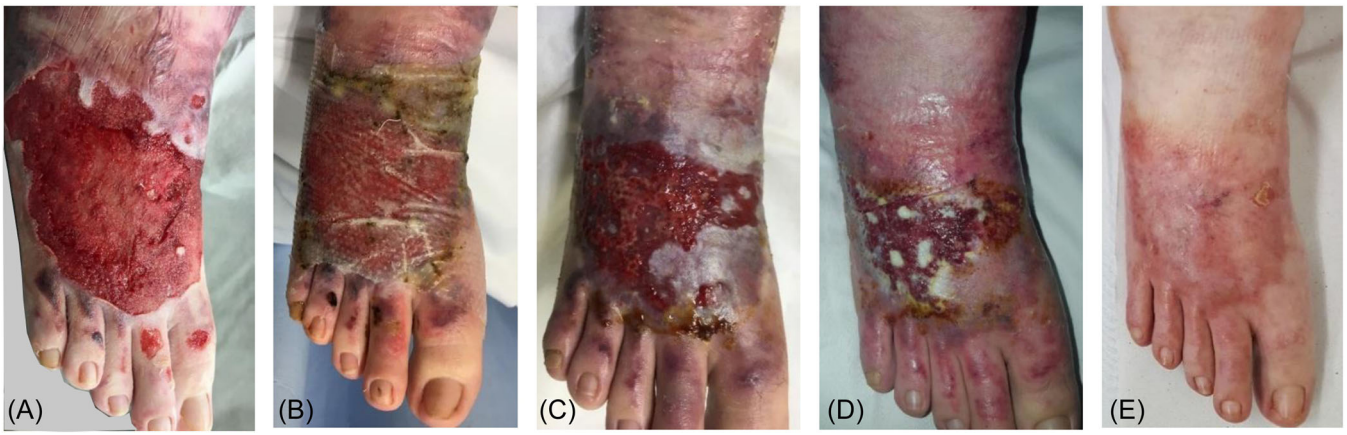

FIGURE 8 Chronic third degree burn with a 134,8 cm^2 wound size. (A) Preoperative appearance. (B) PO7: Epithelial islands are visible. (C) PO21: The "epithelial islands" of cells proliferate and migrate to form a confluent epithelial layer. (D) PO30: Shows progression of healing. (E) PO60: completed healed wound similar to a sheet graft.

prospective randomized studies will have to be carried out in the future. As this is a new procedure and material in our country, although authorized by ANVISA–Agência Nacional de Vigilância Sanitária (Brazilian Health Regulatory Agency), we did not perform the procedure in acute patients with a severe clinical condition and we only performed the study on chronic ulcers of different etiologies, including residual ulcers in burn patients.

We did not have a dermaspectrometer to analyze redness and pigmentation or a cutometer to analyze the pliability and/elasticity so we had to use the Vancouver scale instead.

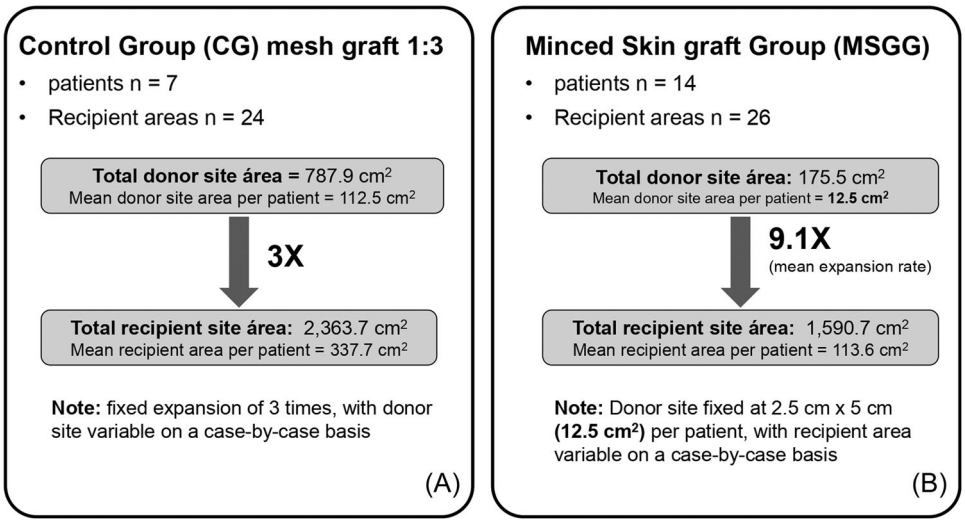

FIGURE 9 (A) CG: expansion ratio (1:3), number of patients, recipient areas, total donor site area and mean area per patient, total recipient site area and mean area per patient. (B) MSGG: number of patients, recipient areas, total donor site area and mean area per patient and total recipient site area and mean area per patient and mean expansion rate.

The study could not be blinded because the cosmetic appearance of the mesh graft is similar to a net fish and the minced skin graft's final cosmetic appearance is similar to sheet grafts and thus any evaluator could see the difference easily.

AUTHOR CONTRIBUTIONS

Débora C. Sanches-Pinto: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; writing—original draft; writing—review & editing. **Elof Eriksson**: Methodology; supervision; validation; writing—review & editing. **David S. Gomez**: Supervision; writing—review & editing. **Maria P. T. Nunes**: Supervision; writing—review & editing. **Rolf Gemperli**: Supervision. **Francisco G. Soriano**: Supervision; validation; writing—review & editing.

ACKNOWLEDGMENTS

The authors are grateful to all the patients and staff participating in this study. The mincer device company (Applied Tissue Technologies) had no role in the study design, data collection, data analysis, data interpretation, writing, or decision to submit the article for publication.

CONFLICT OF INTEREST STATEMENT

Dr Eriksson is the inventor of the Minced Skin Graft technique and he has patented devices and methods for harvesting and processing of skin grafts. He had no part of the design, evaluation or the conclusions of this study. The remaining authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available on request due to privacy/ethical restrictions. The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

TRANSPARENCY STATEMENT

The lead author Débora Cristina Sanches-Pinto affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID

Débora C. Sanches-Pinto https://orcid.org/0000-0001-9496-3024

REFERENCES

1. Eriksson E, Liu PY, Schultz GS, et al. Chronic wounds: treatment consensus. *Wound Repair Regen*. 2022;30:156-171.
2. Frykberg RG, Banks J. Challenges in the treatment of chronic wounds. *Adv Wound Care*. 2015;4:560-582.
3. Hermans MH. Wounds and ulcers: back to the old nomenclature. *Wounds*. 2010;22:289-293.
4. Heyer K, Herberger K, Protz K, Glaeske G, Augustin M. Epidemiology of chronic wounds in Germany: analysis of statutory health insurance data. *Wound Repair Regen*. 2016;24:434-442.
5. Guest JF, Ayoub N, McIlwraith T, et al. Health economic burden that wounds impose on the National Health Service in the UK. *BMJ Open*. 2015;5:e009283.
6. Roger VL. Epidemiology of heart failure. *Circ Res*. 2013;113:646-659.
7. Campos, Jr., W, Torres IO, da Silva ES. A prospective randomized study comparing polidocanol foam sclerotherapy with surgical treatment of patients with primary chronic venous insufficiency and ulcer. *Ann Vasc Surg*. 2015;29:1128-1135.
8. Gomes R, Andrade CC, Dias C, et al. Prevention versus treatment of venous ulcers in Brazilian national health system: how much could be saved? *Value Heath*. 2020;23:S190.
9. Kim Y, Png CYM, Sumpio BJ, DeCarlo CS, Dua A. Defining the human and health care costs of chronic venous insufficiency. *Semin Vasc Surg*. 2021;34:59-64.
10. Sibbald RG, Elliott JA, Persaud-Jaimangal R, et al. Wound bed preparation 2021. *Adv Skin Wound Care*. 2021;34:183-195.

11. Shamsian N. Wound bed preparation: an overview. *Br J Community Nurs*. 2021;26(Sup9):S6-S11.
12. Atkin L. Introducing a new approach to debridement and wound bed preparation. *J Wound Care*. 2022;31(Sup8a):S5-S11.
13. Kim PJ. Understanding wound bed preparation. In: Hong JP, Suh H, eds. *Diabetic Foot Reconstruction: a Practical Guide*. Springer; 2022:43-52.
14. Meek CP. Successful microdermagrafting using the Meek-wall microdermatome. *Am J Surg*. 1958;96:557-558.
15. Tanner JC, Vandeput J, Olley JF. The mesh skin graft. *Plast Reconstr Surg*. 1964;34:287-292.
16. Singh M, Nuutila K, Collins KC, Huang A. Evolution of skin grafting for treatment of burns: reverdin pinch grafting to tanner mesh grafting and beyond. *Burns*. 2017;43:1149-1154.
17. Svensjö T, Pomahac B, Yao F, Slama J, Wasif N, Eriksson E. Autologous skin transplantation: comparison of minced skin to other techniques. *J Surg Res*. 2002;103:19-29.
18. Hackl F, Bergmann J, Granter SR, et al. Epidermal regeneration by micrograft transplantation with immediate 100-fold expansion. *Plast Reconstr Surg*. 2012;129:443e-452e.
19. Hamnerius N, Wallin E, Svensson Å, Stenström P, Svensjö T. Fast and standardized skin grafting of leg wounds with a new technique: report of 2 cases and review of previous methods. *Eplasty*. 2016;16:14.
20. Danks RR, Lairet K. Innovations in caring for a large burn in the Iraq war zone. *J Burn Care Res*. 2010;31:665-669.
21. Singh M, Nuutila K, Kruse C, Dermietzel A, Caterson EJ, Eriksson E. Pixel grafting: an evolution of mincing for transplantation of full-thickness wounds. *Plast Reconstr Surg*. 2016;137(1):92e-99e.
22. Nuutila K, Varon SE, Broomhead M, Eriksson E. Minced skin grafts can be expanded up to 500 times to re–epitheliaze full–thickness burns. *J Burn Care Res*. 2022;43(Suppl 1):S17-P19.
23. Winter GD. Formation of the scab and the rate of epithelization of superficial wounds in the skin of the young domestic pig. *Nature*. 1962;193:293-294.
24. Nuutila K, Eriksson E. Moist wound healing with commonly available dressings. *Adv Wound Care*. 2021;10:685-698.
25. Sullivan T, Smith J, Kermode J, McIver E, Courtemanche DJ. Rating the burn scar. *J Burn Care Rehabil*. 1990;11:256-260.
26. Ehrenfried A. Reverdin and other methods of skin-grafting. *Boston Med Surg J*. 1909;161:911-917.
27. Zuhaili B, Aflaki P, Koyama T, et al. Meshed skin grafts placed upside down can "take" if desiccation is prevented. *Plast Reconstr Surg*. 2010;125:855-865.
28. Lo CH, Akbarzadeh S, McLean C, et al. Wound healing after cultured epithelial autografting in patients with massive burn injury: a cohort study. *J Plast Reconstr Aesthet Surg*. 2019;72:427-437.

How to cite this article: Sanches-Pinto DC, Eriksson E, Gomez DS, Nunes MPT, Gemperli R, Soriano FG. Minced skin grafts for chronic wounds compared to conventional mesh grafts. *Health Sci Rep*. 2023;6:e1353. doi:10.1002/hsr2.1353