ARANDU UTIC
Revista Científica Internacional - Universidad Tecnológica Intercontinental
Revista Científica Internacional
ISSN 2311-7559

Advanced reconstructive techniques for surgical management of extensive skin defects due to post-burn scarring: a systematic review

Técnicas reconstructivas avanzadas para el tratamiento quirúrgico de defectos cutáneos extensos debidos a cicatrices posteriores a quemaduras: una revisión sistemática

Génesis Karolina Huilca Villalba
genitho20@gmail.com
https://orcid.org/0000-0003-2466-3100
Universidad Nacional de Chimborazo
Ecuador

Fernanda Ximena Castro Ibáñez
nandy.castro99@gmail.com
https://orcid.org/0009-0005-8265-5055
Ministerio de Salud Pública
Ecuador

Any Yareli Diaz Carbajal
anyarelidiaz@gmail.com
https://orcid.org/0009-0005-7183-9430
IMSS (Instituto Mexicano del Seguro Social
México

Sebastián David Portilla Muñoz
seseportilla@hotmail.com
https://orcid.org/0009-0002-6574-6906
Universidad Cooperativa De Colombia - Sede Pasto
Colombia

Adlay Jambick Cuello Carranza
seseportilla@hotmail.com
https://orcid.org/0009-0007-3050-3230
Médico General Ayudante Quirúrgico- Clínica La Estancia, Popayán - Cauca.
Colombia

Jaret Damar Ruiz Rodriguez
jaret.drz@outlook.com
https://orcid.org/0009-0000-7361-3260
Centro Médico Noreste UMAE 25 IMSS
Residente de Cirugía General
México

José Javier Alvarez Arroyo
jvr.pzzct@gmail.com
https://orcid.org/0009-0000-6362-3828
Secretaria de salud de México, Universidad Nacional Autónoma De México
Residente de Medicina Interna
México

Artículo recibido: 20 octubre 2024 - Aceptado para publicación: 26 noviembre 2024
Conflictos de intereses: Ninguno que declarar

ABSTRACT

Recent advancements in reconstructive techniques for burn-induced skin defects have improved functional and aesthetic outcomes to enhance life quality of burn survivors. A wide range of innovative methods such as flap surgeries advancements or laser therapies and tissue expansion techniques are now available in the markets and their use has been widely explored for management of extensive post-burn scarring. According to studies the use of latest technological innovations and microvascular free tissue transfer, Z-plasty and trapeze flaps have excellent success rates for contracture release, scar reduction, and functional restoration. Laser treatments that have shown promise in decreasing scar thickness and increasing suppleness include stromal vascular fraction therapy and CO2 fractional lasers. There remain persisting issues like limited long-term data, expense, and technical complexity. In order to evaluate the clinical effectiveness, drawbacks, and potential future directions of these reconstructive techniques in burn care, this review summarizes recent research.

Keywords: reconstructive techniques, skin burns, post-burn scaring, advancements, scar management

RESUMEN

Los avances recientes en técnicas reconstructivas para los defectos cutáneos inducidos por quemaduras han mejorado los resultados funcionales y estéticos para mejorar la calidad de vida de los sobrevivientes de quemaduras. En la actualidad existe en el mercado una amplia gama de métodos innovadores, como las cirugías de colgajos, los avances o las terapias con láser y las técnicas de expansión de tejidos, y su uso se ha explorado ampliamente para el tratamiento de las cicatrices extensas posteriores a las quemaduras. Según los estudios, el uso de las últimas innovaciones tecnológicas y la transferencia de tejido libre microvascular, la plastia en Z y los colgajos de trapecio tienen excelentes tasas de éxito para la liberación de contracturas, la reducción de cicatrices y la restauración funcional. Los tratamientos con láser que se han mostrado prometedores en la disminución del grosor de la cicatriz y el aumento de la flexibilidad incluyen la terapia de fracción vascular estromal y los láseres fraccionados de CO2. Siguen existiendo problemas persistentes, como los datos limitados a largo plazo, los gastos y la complejidad técnica. Con el fin de evaluar la efectividad clínica, los inconvenientes y las posibles direcciones futuras de estas técnicas reconstructivas en el tratamiento de quemaduras, esta revisión resume las investigaciones recientes.

Palabras clave: técnicas reconstructivas, quemaduras cutáneas, cicatrización post-quemadura, avances, manejo de cicatrices

INTRODUCTION

The treatment of extensive post-burn scars is a complex process and these scars cause functional impairments and emotional distress among patients. Severe burns that damages full skin thickness lead to scarring characterized by thick and tight tissue called contractures. These contractures limit movement and these become most troubling around joints and can impact functions like limb mobility and facial expressions. Beyond physical issues these visible scarring also poses psychological challenges and it is seen to increase depression and social withdrawal due to altered appearance and self-image (Goel & Shrivastava, 2010). According to recent statics of 2024 estimated results show that burn injuries lead cause scarring with hypertrophic scars reported in 8% to 67% of cases. A recent study found an 8% prevalence. Contractures, which limit mobility, occur in 38–54% of patients at discharge and decreasing over time. Reconstructive surgery is required in 5–20% of burn victims up to 10 years' post-injury. Burn injury data is scarce but annually the U.S. reports 486,000 burn injuries and 40,000 hospitalizations. In Europe burn hospitalization rates vary from 2 to 29 per 100,000 inhabitants and in Australia, research says that it's 36 per 100,000 (Van Baar, 2020). Newer technologies such as fractional CO_2 and Erbium-YAG lasers have been developed to treat thickened scars and most focus is making them softer and improving flexibility. These lasers work by breaking down excess collagen in scar tissue which helps restore some of the skin's original qualities. The use of autologous stem cell therapies which use the patient's own cells are also being explored to improve skin elasticity and is seen to reduce scarring while restoring more natural skin tone. For areas with severe contractures the use of techniques like tissue expansion provide extra skin without needing additional donor sites in useful in areas with high movement needs like the face or joints. Tissue-engineered products such as Integra and Alloderm, offer supportive frameworks for skin regeneration which gives these scarred areas a chance to heal with healthier and more flexible tissue. Complex cases may require surgical options like trapeze or rotation flaps to restore movement while minimizing tension across joints while these advanced methods carry risks like potential tissue loss or scar recurrence. We warrant for careful planning and technique selection to help surgeons achieve better outcomes for both function and appearance (Futran, 2002).

We aimed to explore and compare most recent techniques available in 2024 for reconstructing burn-related skin defects and we will be covering options like Trapeze flaps, Z-plasty, full-thickness skin grafts, temporo-parietal fascial flaps, fractional CO_2 laser therapy, free tissue transfer, joint scar contracture flaps and many other available options being used in medical centers. We will be examining how these techniques has been previously used by this systematic search and previous trials will be evaluating outcomes, benefits, and limitations of each method including factors like patient satisfaction, functional recovery, appearance, scar quality, and complication rates. We hope to clarify which techniques offer the most effective solutions.

MATERIALS AND METHODS

We have decided a rigorous research type which will be based on previous systematic reviews, meta-analysis, clinical trials, case series, and cohort studies for focused research that examine advanced surgical treatments for severe post-burn scarring. Each study selected had to meet clear inclusion criteria as it needed to address patients with extensive burns resulting in functionally or aesthetically scarring and describe specific surgical interventions. Studies about minor burns, non-surgical treatments or less comparable techniques were left out to keep the review tightly centered on relevant surgical outcomes. Only papers published in English is were considered, specifically from last decade, yet our focus was more on papers which are published from timeline 2023-24. Only peer-reviewed original papers are considered which must discuss a clear methodology and results. Other results were excluded.

Table 1

Data Sources and Search Strategy and Data Extraction

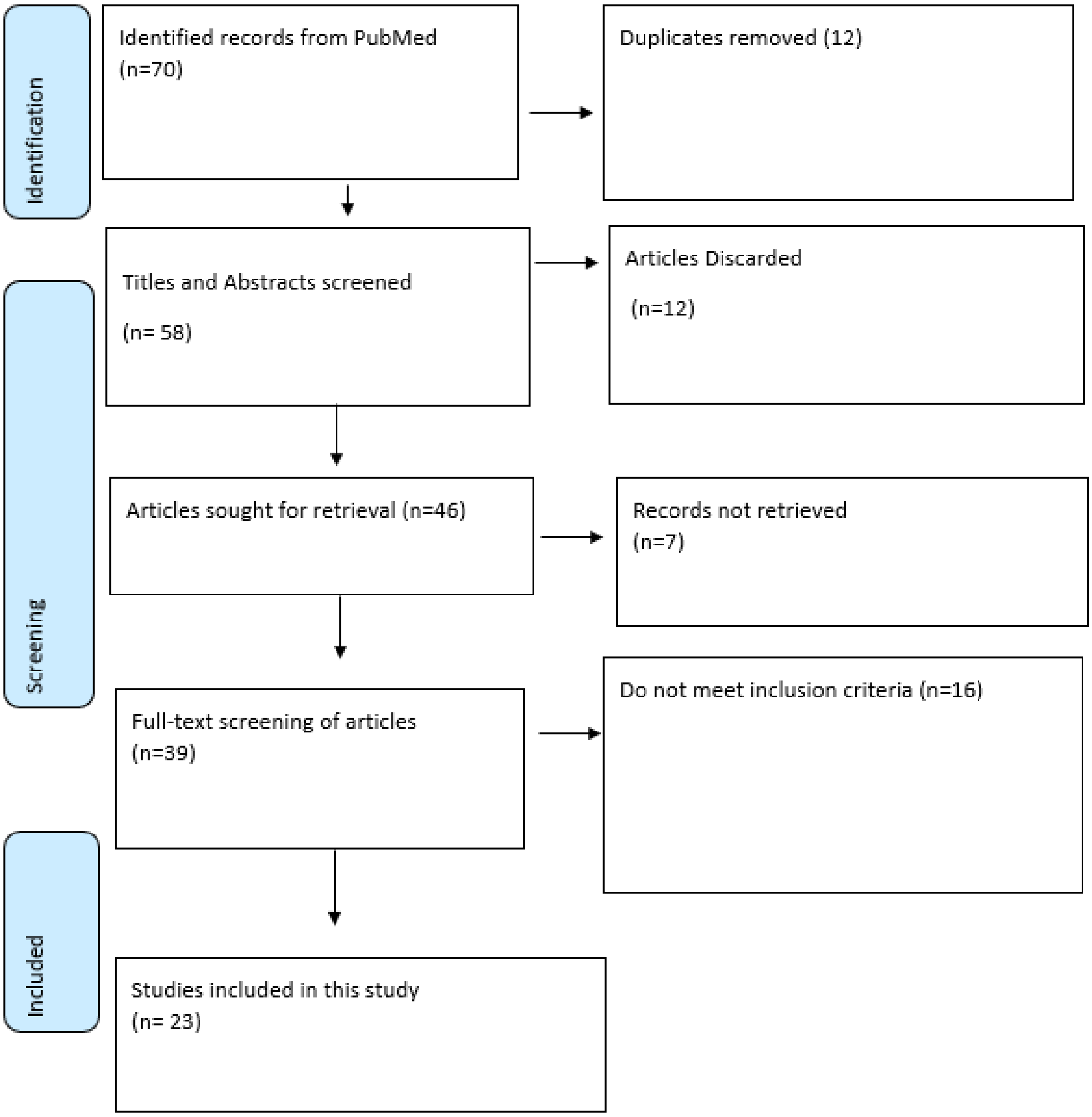
Primary Key Terms	Secondary Key Terms
Advanced reconstructive techniques, Surgical management	Complex reconstructive methods, Surgical repair techniques
Extensive skin defects, Post-burn scarring	Large area skin injuries, Burn scar revision, Post-burn scar deformities
Burn scar contractures	Scar contracture release, Severe burn wound management
Functional and aesthetic outcomes	Functional and cosmetic restoration, Advanced scar treatment
Severe burn management	Burn scar revision, Surgical treatment of burn sequelae
Surgical techniques (e.g., grafting, flaps, tissue expansion)	Laser therapy, Stem cell application, Complex reconstructive methods

Major string: Major string designed for PubMed was *("Advanced Reconstructive Techniques" OR "Complex Reconstruction Methods" OR "Innovative Reconstructive Surgery" OR "Novel Reconstruction Approaches" OR "Advanced Surgical Repair") AND ("Surgical Management" OR "Operative Treatment" OR "Surgical Repair" OR "Reconstructive Surgery") AND ("Extensive Skin Defects" OR "Large Skin Defects" OR "Extensive Dermal Damage" OR "Severe Skin Injuries") AND ("Post-Burn Scarring" OR "Burn-Related Scarring" OR "Burn Scars" OR "Post-Thermal Injury" OR "Thermal Injury Scarring" OR "Scarring Due to Burns" OR "Burn Wound Sequelae") OR ("Thermal Burns" OR "Chemical Burns" OR "Electrical Burns"*

OR "Flame Burns" OR "Radiation Burns" OR "Heat-Related Skin Damage" OR "Hot Water Burns" OR "Scald Injuries").

Figure 1

Prisma Flow Diagram Of Included Studies



After the decision of included papers, we manually recorded which surgical techniques was employed and measurable outcomes such as functional recovery, aesthetic improvement and complication rates or what possible limitations remains. Our primary objective was recording success rate of each technique being employed. Extracted data focused on reconstructive methods like trapeze flaps, Z-plasty, full-thickness skin grafts, and laser therapy, among others. Data from each study were systematically charted for a comparative analysis of effectiveness, patient satisfaction, and recurrence of scarring.

RESULTS AND DISCUSSION

Table 2

Recent advancements in reconstructive techniques for burn-induced skin defects

Technique	Study Details	Advancement/Outcomes	Limitations
Trapeze Flap	Fattah (2022) - Kurdistan, Iraq	Achieved high patient satisfaction (97%) for flexion contracture severity. High satisfaction rate with full-thickness skin graft (96%) (p=0.20)	Not statistically significant results
Z-Plasty for Scar Management	Dastagir et al. (2021) - Germany	Effective in reducing scar conspicuousness and aiding scar contraction prevention	Challenges in scar lengthening and aligning with relaxed skin lines
Total Full-Thickness Skin Grafts	Bogdanov et al. (2020) - Russia	Enhanced autograft engraftment with lower long-term fibrosis, superior cosmetic outcomes	Applicable to facial burns; potential limitations for larger body areas
Temporo-Parietal Fascial Flap	Bhandari & Singh (2020) - India	Excellent outcomes for ear reconstruction; minor complications in 11 cases	Partial and complete flap loss in some cases
Fractional CO2 Lasers	Issler-Fisher et al. (2020) - Australia	Significant reduction in scar thickness, improved body image, and quality of life	Complications in 2.9% of cases
Free Tissue Transfer (FTT)	Brewin et al. (2020) - UK	High success in secondary scar reconstructions; common use of anterolateral thigh and parascapular flaps	Hypertrophic scarring observed in 17% of cases
Joint Burn Scar Contracture Flap	Ma et al. (2021) - Nanjing Medical University, China	Lower recontracture rate (10% vs. 27.1%) compared to skin grafts, with higher functional satisfaction (p=0.043)	Limited long-term comparative data
Fractional Ablative Laser Therapy	Miletta et al. (2019) - USA	Improvement in elasticity, scar thickness, and vascularity;	Limited data on effectiveness across scar types

		significant pigmentation and thickness reduction	
CO2 Laser + Stromal Vascular Fraction (SVF)	Roohaninasab et al. (2023) - Iran	Combined therapy outperformed laser alone; Vancouver scar scale reduction (p=0.007)	Availability and costs of SVF treatment
Hydrosurgical Debridement	Legemate et al. (2021) - Netherlands	Preserved dermal layer, improved scar pliability resembling normal skin (p=0.029, p=0.039)	Requires specialized equipment
Laser Therapy in Pediatrics	Bergus et al. (2024) - Nationwide Children's Hospital, Ohio	Notable reductions in Vancouver scar scale scores across various body areas	Limited to pediatric cases; variable outcomes based on scar location
Full-Thickness vs. Split-Thickness Grafts	Alsaif et al. (2023) - Systematic Review	FTSG reduced post-graft contracture risk (OR=0.35, p=0.0001) and need for surgical release; functional recovery superior	STSG showed better cosmetic outcomes
Perforator-Based Flaps	Stekelenburg et al. (2017) - Multicenter RCT	Outperformed full-thickness grafts in surface area maintenance (p < 0.001) and scar quality; recommended for elasticity	Requires advanced surgical skill
Island vs. Skin-Pedicled Flaps	Yoshino et al. (2018) - Japan	Skin-pedicled flaps demonstrated higher extensibility post-surgery, effective for larger contracture release	Island flaps are less extensible but technically simpler
Microvascular Free Tissue Transfer	Soto et al. (2024) - Chile	High survival rate (97%) in primary burn reconstruction, effective single-stage coverage	Higher complexity and costs
External Tissue Expansion	Tong et al. (2022) - Systematic	High wound healing rates, particularly effective for fasciotomy defects (93%+ success)	Complications (15.7%), especially in open abdomen cases

	Review and Meta-analysis		
Minimally Invasive Contracture Release (MICBR)	Blome-Eberwein et al. (2024) - Retrospective Study	Significant ROM gains, 95% reported improved mobility, minimal adverse events	Limited to specific anatomical sites; needs further study for larger application

The results of this systematic review on advanced reconstructive techniques for extensive skin defects post-burn provide data from a range of studies have shown multiple advancements in reconstructive techniques but there remain certain gaps. Our results show that in Kurdistan, Iraq, Fattah (2022) investigated Trapeze flap for treating flexion contractures while reporting 97% patient satisfaction with severity improvements ($p=0.77$). Using the Trapeze flap alone or with full-thickness skin grafts have yielded similarly high satisfaction at 96% but statistical significance ($p=0.20$) was not obtained. Similarly, in another research by Dastagir et al which was conducted in 2021 in Germany demonstrated that a Z-plasty-based algorithm effectively minimized scar prominence by creating irregular scar tissue patterns and was seen that it aided in scar contraction control but issues with scar lengthening and positioning within relaxed skin lines were noted. Bogdanov et al. (2020) in his research has talked about effectiveness of full-thickness skin grafts in Russia for facial burn repair which he can be seen achieving high autograft success rates and reducing fibrosis risk which led to superior cosmetic results. In India, Bhandari and Singh (2020) reported favorable outcomes using the temporo-parietal fascial flap for ear reconstruction although partial flap loss occurred in 11 cases with one case of complete flap loss. Issler-Fisher et al. (2020) conducted a study in Australia on the effects of ablative fractional CO_2 lasers on burn scars where it was found that these lasers improved scar thickness, subjective parameters and quality of life while improving Body Image and Heat Sensitivity scores. In just 2.9% of cases, complications occurred. Free tissue transfer (FTT) for secondary burn reconstructions was examined by Brewin et al. (2020) in the UK, and they found that it had a high success rate with only one flap failure. Preexpanded parascapular (43%) and anterolateral thigh (57%) flaps were common and 17% of patients had hypertrophic scarring. In China, Ma et al. (2021) evaluated flap vs. full-thickness skin graft outcomes for joint burn scar contractures, and this research has seen great progress in lowering re-contracture rate in the flap group (10%) compared to full-thickness grafts (27.1%) after one year ($p=0.043$). They also recorded that flap use yielded functional satisfaction with recontracture rates remaining low at five years (4.8% vs. 26.9%). In 2019, another research is reported in the United States by Miletta et al. where it was observed that fractional ablative laser therapy improved elasticity, scar thickness and life quality parameters. There were noticeable improvements in thickness, pigmentation, and vascularity. Another evidence show that by lowering the Vancouver scar scale from 7.40 to 5.90 (p=0.007) and considerably increasing skin density Roohaninasab et al. (2023) discovered that fractional CO2 laser in conjunction with stromal vascular fraction (SVF) therapy was more successful in Iran than laser therapy alone. Hydrosurgical debridement produced better scar pliability than conventional techniques according to a multicenter Dutch study led by Legemate et al. (2021) and these results closely matched normal skin pliability (p=0.029 and p=0.039) preserved the dermal layer, and produced few complications. Bergus et al. (2024) reported that pediatric laser-treated patients at Nationwide Children's Hospital in Ohio had significantly lower Vancouver scar scale scores which is indicating scar improvement in a variety of body locations. A systematic study comparing split-thickness grafts (STSG) and full-thickness skin grafts (FTSG) for pediatric hand burns was carried out by Alsaif et al. in 2023 where it was found that FTSG significantly reduced the requirement for surgical release (OR = 0.06, p=0.00001) and post-graft contracture (OR = 0.35, p=0.0001) after analyzing 532 grafts from ten investigations. STSG produced superior cosmetic results with less hair regrowth whereas FTSG demonstrated greater functional recovery. For extensive post-burn skin defects, local flaps such as random pattern flaps, axial pattern flaps, and perforator-based flaps can be chosen. Random pattern flaps which rely on subdermal vascularity are seen to be more suited for smaller defects. Axial pattern flaps like the groin or deltopectoral flap have a specific arterial supply for greater reliability in larger areas. Perforator-based flaps such as the anterolateral thigh flap can provide us more versatility with minimal donor-site damage but require technical precision. For the relaxation of contractures, particularly around joints the use of Z-plasty and comparable techniques are helpful. Perforator-based interposition flaps were compared to full-thickness grafts for the release of burn scar contracture in a 2017 multicenter, RCT by Stekelenburg et al concluded. The results showed that perforator flaps improved scar quality on the Patient and Observer Scar Assessment Scale and maintained surface area better (123% vs. 87% at 3 months, 142% vs. 92% at 12 months; $p < 0.001$). Better contracture release results were a result of perforator flaps' increased vascularity and flexibility. In 2018, a study by Yoshino et al. evaluated island versus skin-pedicled flaps for chest, axilla, and limb contractures, has provided us a piece of significant information that skin-pedicled flaps provided greater post-surgical extensibility (1.53-fold vs. 1.28-fold), island flaps were reported to present fewer technical difficulties but were less effective for contracture release which makes it clear that skin-pedicled flaps may be more appropriate for larger releases due to superior flexibility. Recently, another research of 2024 which is named as Chilean study by Soto et al examined about microvascular free tissue transfer for primary burn reconstructions at a burn center as results reported of 925 admissions about 5.1% required free flaps mostly anterolateral thigh flaps with an average reconstruction time of 39 days. Reported complications occurred in 21% of cases and flap survival was high with only one case of flap loss (2.9%) which means microvascular flaps in acute burn settings for their efficacy in single-stage defect coverage despite higher complexity and costs. Tong et al. (2022) conducted meta-analysis on external tissue expansion for soft tissue defect management where he covered 66 studies with varied expansion devices. Results by Tong review demonstrated that healing rates were high averaging 93% across defect types though lower for open abdominal defects (68.8%). Healing time varied by cause from 10.5 days for fasciotomy defects to 48.8 days for open abdomen cases. Complication rates were 15.7%, primarily from dehiscence (3.14%) which indicating that while external expansion is effective while further trials are needed to confirm long-term benefits. A current evidence which is conducted in 2024 by Blome-Eberwein et al. has evaluated minimally invasive contracture release (MICBR) in 45 patients with post-burn scarring across 97 contracture sites while improvements in range of motion (ROM) were substantial with 95% of patients reporting enhanced mobility and 84% expressing satisfaction. Complications rate was being minimal thus this study supports MICBR as a promising alternative for contracture release in extensive burns.

Emerging technologies for Post Burning scaring

Emerging advanced reconstructive techniques for surgical management of those people who got severe skin defects or high level of contractures caused by burns have made notable progresses and patients' outcomes have been improved. 3D bio printing, as discussed in Varkey et al. (2019) research have allowed physicians for precise fabrication of skin layers using patient-derived cells which also has enhanced graft integration and minimizing rejection. Now there are hydrogel-based scaffolds are being used to support cell proliferation and skin regeneration which has made healing process higher. Another emerging technique is the use of platelet-rich plasma (PRP) therapy which is mostly used because it stimulates collagen production and angiogenesis and it is seen to reduce scarring. Scientists have been working of the use of stem cell therapy and they have really pushed its use to the forefront particularly from adipose or bone marrow sources as it fosters wound repair by promoting tissue regeneration and reducing fibrosis. Fractional lasers use in laser-assisted scar modification has increased flexibility while decreases scar thickness on the other hand and one plus point is that it also works to reduce discoloration. Oxygen therapy combined with silicone-based dressings speeds up re-epithelialization while preserving moisture balance. AlloDerm and Integra two skin substitutes can improve wound healing and offer structural support. Wound dressings based on nanotechnology encourage tissue healing and provide antibacterial protection. The use of negative pressure wound therapy or NPWT is also a significant advancement as it eliminates exudate and promotes blood flow and promote healing (Ataide et al., 2022). Extracellular matrix (ECM) therapy promotes tissue regeneration and prevents the development of scars and cellular repair processes are stimulated by electromagnetic treatment (EMT). Gene therapy targets the genetic pathways that cause fibrosis whereas another major advancement are synthetic dermal templates, which aid in skin regeneration. By improving the amount of oxygen delivered to wound sites, oxygen-enhanced hydrogel dressings speed up the healing process. The use of gels based on bioactive peptides promotes healing and speed up cellular migration and lessens scarring and enhances functional recovery (Kolimi, 2022).

CONCLUSIONS

We have seen a notable advancement in both esthetic and functional results but the field of reconstructive treatments for post-burn skin abnormalities is still developing. Although they are more expensive and technically demanding but methods like free tissue transfer and laser therapy have produced excellent outcomes and are safe to choose. Perforator-based flaps and fractional CO2 lasers are two examples of innovations that are showing promise but further studies and researches can improve their use in a variety of patient populations. These methodologies show enormous potential to improve long-term results for people with severe burn injuries and these are more widely available and improved. A major obstacle to attaining the best outcomes in burn care settings is the requirement for customized strategies that take patient-specific characteristics and resource availability into account.

REFERENCES

Fattah, J. H. (2022). Reconstruction of Post-burn Hand Contractures with Trapeze Flap and Evaluation of the SDF1 Gene Expression. *Cellular and Molecular Biology*, *68*(4), 170–177. https://doi.org/10.14715/cmb/2022.68.4.20

Dastagir, K., Obed, D., Bucher, F., Hofmann, T., Koyro, K. I., & Vogt, P. M. (2021). Non-Invasive and Surgical Modalities for scar Management: a Clinical algorithm. *Journal of Personalized Medicine*, *11*(12), 1259. https://doi.org/10.3390/jpm11121259

Bogdanov, S. B., Gilevich, I. V., Melkonyan, K. I., Sotnichenko, A. S., Alekseenko, S. N., & Porhanov, V. A. (2020). Total full-thickness skin grafting for treating patients with extensive facial burn injury: A 10-year experience. *Burns*, *47*(6), 1389–1398. https://doi.org/10.1016/j.burns.2020.12.003

Bhandari, P. S., & Singh, S. (2020). Tips and tricks of temporo-parietal fascial flap in post burn ear reconstruction. *Burns Open*, *4*(4), 146–152. https://doi.org/10.1016/j.burnso.2020.08.002

Issler-Fisher, A. C., Fisher, O. M., Haertsch, P. A., Li, Z., & Maitz, P. K. (2020). Effectiveness and safety of ablative fractional CO2 laser for the treatment of burn scars: A case-control study. *Burns*, *47*(4), 785–795. https://doi.org/10.1016/j.burns.2020.10.002

Brewin, M., Hijazi, Y., Pope-Jones, S., Exton, R., & Khan. (2020). Free tissue transfer for burns reconstruction: A single-site experience. *Burns*, *46*(7), 1660–1667. https://doi.org/10.1016/j.burns.2020.04.001

Ma, Z., Mo, R., Chen, C., Meng, X., & Tan, Q. (2021). Surgical treatment of joint burn scar contracture: a 10-year single-center experience with long-term outcome evaluation. *Annals of Translational Medicine*, *9*(4), 303. https://doi.org/10.21037/atm-20-4947

Miletta, N., Siwy, K., Hivnor, C., Clark, J., Shofner, J., Zurakowski, D., Anderson, R. R., Lee, K., & Donelan, M. (2019). Fractional Ablative Laser Therapy is an Effective Treatment for Hypertrophic Burn Scars. *Annals of Surgery*, *274*(6), e574–e580. https://doi.org/10.1097/sla.0000000000003576

Roohaninasab, M., Khodadad, F., Sadeghzadeh-Bazargan, A., Atefi, N., Zare, S., Jafarzadeh, A., Rahimi, S. T., Nouri, M., Nilforoushzadeh, M. A., Behrangi, E., & Goodarzi, A. (2023). Efficacy of fractional CO2 laser in combination with stromal vascular fraction (SVF) compared with fractional CO2 laser alone in the treatment of burn scars: a randomized controlled clinical trial. *Stem Cell Research & Therapy*, *14*(1). https://doi.org/10.1186/s13287-023-03480-8

Legemate, C. M., Kwa, K. a. A., Goei, H., Pijpe, A., Middelkoop, E., Van Zuijlen, P. P. M., Beerthuizen, G. I. J. M., Nieuwenhuis, M. K., Van Baar, M. E., Van Der Vlies, C. H., Dokter, J., Gardien, K. L. M., Hiddingh, J., Hofland, H. W. C., Lucas, Y., Vries, A. M., Nijhuis, T. H. J., Oen, I. M. M. H., Roodbergen, D. T., . . . Trommel, N. (2021). Hydrosurgical and conventional debridement of burns: randomized clinical trial. *British Journal of Surgery*, *109*(4), 332–339. https://doi.org/10.1093/bjs/znab470

Bergus, K. C., Iske, T., Fabia, R., Schwartz, D., & Thakkar, R. K. (2024). Impact of laser treatment on hypertrophic burn scars in pediatric burn patients. *Burns*, *50*(7), 1863–1870. https://doi.org/10.1016/j.burns.2024.04.010

Alsaif, A., Karam, M., Hayre, A., Abul, A., Aldubaikhi, A., & Kahlar, N. (2022). Full thickness skin graft versus split thickness skin graft in paediatric patients with hand burns: Systematic review and meta-analysis. *Burns*, *49*(5), 1017–1027. https://doi.org/10.1016/j.burns.2022.09.010

Yoshino Y, Kubomura K, Ueda H, Tsuge T, Ogawa R. Extension of flaps associated with burn scar reconstruction: A key difference between island and skin-pedicled flaps. Burns [Internet]. 2017 Oct 28;44(3):683–91. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0305417917305053

Carolina S, Jimena D, Adriana A, Ekaterina T, José HM, Diego G, et al. The introduction of microvascular free tissue transfer in primary burn reconstruction. Experience report of the national burn center in Chile. Burns Open [Internet]. 2024 Mar 28;8(3):169–74. Available from: https://www.sciencedirect.com/science/article/pii/S2468912224000221

Xirui Tong, Jianyu Lu, Wei Zhang, Siqiao Wang, Runzhi Huang, Xianliang Zhang, Jie Huang, Yushu Zhu, Shichu Xiao, Shizhao Ji, Zhaofan Xia, Efficacy and safety of external tissue expansion technique in the treatment of soft tissue defects: a systematic review and meta-analysis of outcomes and complication rates, *Burns & Trauma*, Volume 10, 2022, tkac045, https://doi.org/10.1093/burnst/tkac045

Stekelenburg CM, Jaspers MEH, Jongen SJM, Baas DC, Gardien KLM, Hiddingh J, et al. Perforator-Based interposition flaps perform better than Full-Thickness grafts for the release of burn scar contractures: a multicenter randomized controlled trial. Plastic & Reconstructive Surgery [Internet]. 2017 Feb 1;139(2):501e–9e. Available from: https://pubmed.ncbi.nlm.nih.gov/28121892/

Blome-Eberwein SA, Schwartz A, Ferdock M, Starner S, Gogal C. Minimally invasive burn reconstruction with subcutaneous scar contracture release. Burns [Internet]. 2024 Mar 22;50(6):1597–604. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0305417924000949

Goel, A., & Shrivastava, P. (2010). Post-burn scars and scar contractures. *Indian Journal of Plastic Surgery*, *43*(3), 63. https://doi.org/10.4103/0970-0358.70724

Van Baar, M. E. (2020). Epidemiology of scars and their consequences: burn scars. In *Springer eBooks* (pp. 37–43). https://doi.org/10.1007/978-3-030-44766-3_5

Futran, N. D., Wadsworth, J. T., Villaret, D., Farwell, D. G., Genden, E. M., Wallace, D., & Buchbinder, D. (2002). Head and neck reconstruction. *Br J Oral Maxillofac Surg*, *40*, 183-190.

Kolimi, P., Narala, S., Nyavanandi, D., Youssef, A. A. A., & Dudhipala, N. (2022). Innovative treatment strategies to accelerate wound healing: trajectory and recent advancements. *Cells*, *11*(15), 2439.

Varkey, M., Visscher, D. O., Van Zuijlen, P. P. M., Atala, A., & Yoo, J. J. (2019). Skin bioprinting: the future of burn wound reconstruction? *Burns & Trauma*, *7*. https://doi.org/10.1186/s41038-019-0142-7

Ataide, J. A., Zanchetta, B., Santos, É. M., Fava, A. L. M., Alves, T. F. R., Cefali, L. C., Chaud, M. V., Oliveira-Nascimento, L., Souto, E. B., & Mazzola, P. G. (2022). Nanotechnology-Based dressings for wound management. *Pharmaceuticals*, *15*(10), 1286. https://doi.org/10.3390/ph15101286