

PLASTIC SURGICAL TECHNIQUES FOR THE TREATMENT OF BURN ABNORMAL SCARS IN PEDIATRIC PATIENTS

Chiubra Pricope¹, Sidonia-Petronela Susanu¹, Ioana-Cezara Caba², B. Caba^{1,3*}

“Sf. Maria” Emergency Children Hospital, Iasi

1. Department of Plastic Surgery

“Grigore T. Popa” University of Medicine and Pharmacy Iasi

Faculty of Pharmacy

2. Department of Toxicology

Faculty of Medical Bioengineering

3. Department of Biomedical Sciences

*Corresponding author. E-mail: bogdan-caba@umfiasi.ro

PLASTIC SURGICAL TECHNIQUES FOR THE TREATMENT OF BURN ABNORMAL SCARS IN PEDIATRIC PATIENTS (Abstract): Post-burn scars have a major impact on the quality of life of pediatric patients, both from a psychological and functional point of view. Pediatric patients with post-burn scars usually have difficulties integrating into the collective due to the low self-esteem determined by the poor aesthetic outcome of the deep or large burns. From a functional standpoint, burn contractures are a significant cause of disability in burn survivors worldwide, as they can affect the tendons and muscles or impair joint mobility. The statistical information that results from this study plays a role in improving the therapeutic protocol. The reconstruction methods of post-burn abnormal scars can be used in order to prevent or to treat the psychological consequences and the functional disability of the affected segment. **Material and methods:** The study includes a group of 147 patients aged between 1-24 years, male and female, admitted through the emergency or outpatient service in the Department of Plastic Surgery and Reconstructive Microsurgery in the “Sf. Maria” Emergency Children Hospital Iasi. **Results:** From the total number of pediatric patients with post-burn scarring sequelae (n=147), 32.65% (n=48) were treated by local triangular skin flaps plasty, 18.36% (n=27) by full-thickness skin graft plasty, 12.92% (n=19) by scar excision and suture, 11.56% (n=17) by tissue expander implant, 7.48% (n=11) by employing the Z-plasty technique, 5.44% (n=8) by associating a local triangular skin flap with a full-thickness skin graft, 5.44% (n=8) by combining Z-plasty with a full-thickness skin graft, 2.04% (n=3) benefited from plasty with synthetic dermis (Integra®), 1.36% (n=2) were treated by degranulation, 1.36% (n=2) by Triamcinolone injection, less than 1% (n=1) of patients received dermabrasion or hair transplantation. **Conclusions:** Skin flaps represent the most effective and frequently utilized method of treatment of post-burn scar sequelae. **Keywords:** BURNS, HYPERTROPHIC SCARS, KELOID SCARS, SKIN FLAPS, SKIN GRAFTS, EXPANDER, Z-PLASTY.

Burns represent one of the most frequent causes of accidental injuries and are a life-threatening and potentially disabling

pathology with major psychological and social implications.

The essential therapeutic objectives are

the survival of the patient, prevention of complications of the acute phase, preservation of the functions of the affected segments, an acceptable cosmetic result, and limitation of psychological trauma (1). Approximately 90% of burns in pediatric patients occur at home, while in adolescents there is a higher rate of occurrence outside of the home (2). An accurate assessment of the extent of burns is critical because resuscitation efforts are based on the affected body surface area. Overestimating or underestimating the surface area of burns can lead to therapeutic failure. Computer applications such as the SAGE chart can provide more accurate assessments (3).

There are multiple methods used for treating burn injuries: skin grafting combined with negative pressure therapy, skin flaps, tissue expanders, artificial dermis, and stem cell therapies. Management practices regarding burn wound healing include initial wound assessment, debridement, dressing, and reconstruction with primary or secondary closure, skin grafts or flaps (4, 5). Skin grafts are divided into 4 categories: autograft, allograft, xenograft, and artificial skin (6). Skin flaps differ from skin grafts by their mobilization along with preserving the vascular source (5). A flap may comprise skin, skin and muscle, muscle and bone, or various combinations of tissues. Flap techniques are based on the local angiosome vascular anatomy (7). Tissue expander reconstruction was originally used for breast reconstruction, but later found utility in the reconstruction of excisional defects resulting from a variety of causes, including postburn surgery. The tissue expander is a silicone balloon with an injection port that allows the injection of a saline solution that will increase its vol-

ume and consequently expand the healthy adjacent tissue (8). Compared to other techniques, such as skin grafting or flap transfers, tissue expansion allows a better match of skin color and texture, in addition, to preserving hair follicles and sensory nerves (9, 10). In terms of artificial dermis utilized in post-burn sequelae treatment, there are several types such as Integra[®], Matriderm[®], or Pelnac[®] (11, 12, 13).

The aim of this study is to highlight the modern methods of treatment of post-burn sequelae and to improve therapeutic conduct to prevent psychological trauma and functional impotence of the affected segment.

MATERIAL AND METHODS

The study includes a group of 147 patients aged between 1-24 years, male and female, admitted through the emergency or ambulatory service in the Department of Plastic Surgery and Reconstructive Microsurgery in the "Sf. Maria" Emergency Children Hospital from Iași, between the years 2010-2020, most of which were admitted repeatedly. Data was collected from observation charts from the hospital's archives and the patient's attending physicians. The collected data comprised of date of birth, age, sex, living conditions, history of burns, and surgical therapeutic plan to which was added information from the observation protocols for patients during the hospital stay and periodical surgeries that were performed. Also, the study was carried out respecting ethical norms, by protecting the confidentiality of the information and the anonymization of the patients in the database. All patients benefited from paraclinical explorations consisting of collecting the usual analyses: complete blood count, inflammatory markers (ESR,

CRP), urea, creatinine, blood glucose, transaminases, exploration of hydro electrolytic and acid-base metabolism, urine summary, coagulation tests, blood group, Rh and imaging studies such as lung X-ray to identify the presence of disorders that may delay surgical intervention and their correction. Moreover, in the morning before surgery, an intensive care physician performed a full pre-anesthetic check-up to assess the anesthetic-surgical risk.

RESULTS

The incidence of hypertrophic scars at 86% (n=127) is six times higher compared to that of keloid scars at 14% (n=20) (fig. 1).

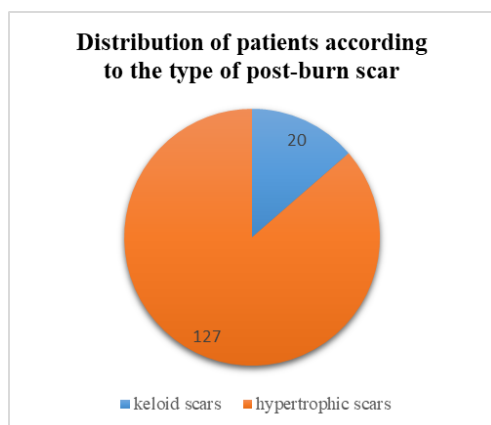


Fig. 1. Distribution of patients according to the type of post-burn scar

From the total number of pediatric patients with post-burn scarring sequelae (n=147), 32.65% (n=48) were treated by local triangular skin flaps plasty, 18.36% (n=27) by full-thickness skin graft plasty, 12.92% (n=19) by scar excision and suture, 11.56% (n=17) by tissue expander implant, 7.48% (n=11) by employing the Z-plasty technique, 5.44% (n=8) by associating a local triangular skin flap with a full-thickness skin graft, 5.44% (n=8) by com-

bining Z-plasty with a full-thickness skin graft, 2.04% (n=3) benefited from plasty with synthetic dermis (Integra®), 1.36% (n=2) were treated by degranulation, 1.36% (n=2) by Triamcinolone injection, less than 1% (n=1) of patients received dermabrasion or hair transplantation (tab. I).

TABLE I
Distribution of patients according to the surgical intervention of postburn scar sequelae

Type of surgery	Cases
Dermabrasion	1
Hair transplant	1
Degranulation	2
Triamcinolone injection	2
Synthetic dermis	3
Combination of skin flap and skin graft	8
Combination of Z-plasty and skin graft	8
Z-plasty	11
Expander implantation	17
Scar excision	19
Skin graft	27
Triangular skin flap	48

In fig. 2, we note that 45% (n=9) of the patients diagnosed with keloid scars benefited from local triangular skin flap plasty. This indicates that this method of treatment for post-burn keloid scars is both commonly used and very effective. And even though the patient group is scant and poses low statistical significance, it still confirms the hypothesis that skin flaps are the most used method of reconstruction of post-burn scar sequelae. Also, 20% (n=4) of these patients were treated by scar excision and suture, 10% (n=2) by full-thickness skin graft plasty, another 10% (n=2) by tissue expander implantation, 5% (n=1) by combining Z-plasty with a full-thickness skin graft.

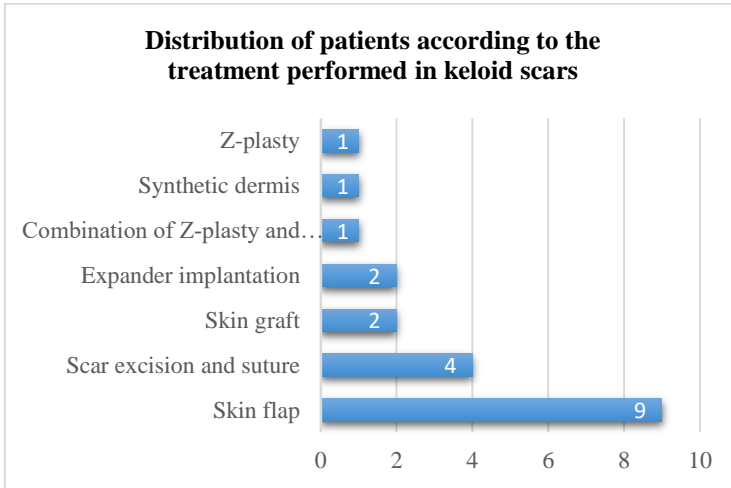


Fig. 2. Distribution of patients according to the treatment performed in keloid scars

The graphic representation in fig. 3, illustrates that 31.49% (n=40) of the patients diagnosed with hypertrophic scars benefited from a local crossed triangular skin flap plasty. This result confirms the previously presented idea: skin flaps are the most used method for the reconstruction of post-burn scar sequelae because they maintain their

vascular source with mobilization, unlike skin grafts that are avascular and require a well-vascularized wound bed.

In figures 4 and 5, the pictures describes a case of post-burn syndactyly at 3/4 fingers and a case with retractable hypertrophic post-burned cervical scar, both treated with local flaps.

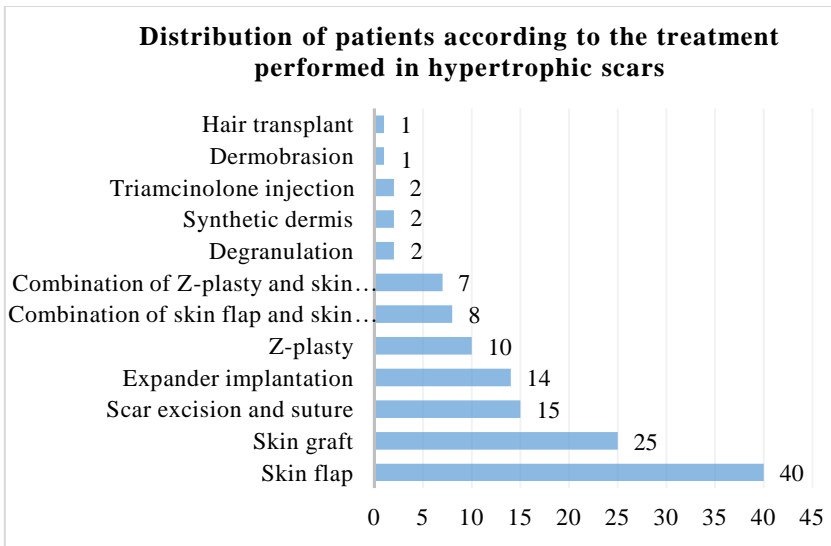


Fig. 3. Distribution of patients according to the treatment performed in hypertrophic scars



Fig. 4. Post-burn syndactyly at 3/4 fingers



Fig. 5. Retractable post-burn hypertrophic scar

Also, 19.68% (n=25) of the patients diagnosed with postburn hypertrophic scars benefited from full-thickness skin graft plasty, 11.81% (n=15) from scar excision and suture, 11.02% (n=14) of implantation with an expander, 7.87% (n=10) of Z-plasty, 6.29% (n=8) from a combination of skin flap with a skin graft, 5.51% (n=7) Z-plasty and skin graft association, under 2% of the patients benefited either from scar degranulation, artificial dermal substitute (Integra®), Triamcinolon injection, dermabrasion or hair transplantation.

It is observed that 45% of patients diagnosed with post-burn keloid scar sequelae benefited from treatment with crossed triangular skin flaps and 10% from skin grafting, as a result, the most common method of skin plasty is flap plasty with a flap:graft ratio of 4.5:1. This difference was found to be statistically significant ($p=0.03$). Also, 31.5% of patients diagnosed with hypertrophic scar benefited from plasty through crossed triangular skin flaps, as opposed to 19.7% of patients who benefited from plasty with skin graft, with a flap:graft ratio of 1.6:1. This difference was found to be statistically significant ($p=0.03$).

DISCUSSION

We observe in the results of our study that the most common post-burn scar sequela developed in pediatric patients is the hypertrophic scar with a percentage of 86% (n=127) of the total number of patients included in the group (n=147), followed by the keloid scar with a percentage of 14% (n=20), hypertrophic scar: keloid ratio of 6.35:1. This confirms the involvement of the genetic factor in the pathogenesis of keloid scars, according to the study by Gurtner *et al.* in 2018 in which he specifies that keloid scars occur more frequently in pigmented individuals and in African populations. These types of sequelae produce patients with functional impotence if the burn is located at or near a joint. Atrophic scars are not present in our group of patients because this type of scar occurs more frequently after a trauma, and less often due to post-burn (7).

Since the intention of this study is to discover the modern methods of treatment for post-burn scar sequelae in pediatric patients, the initial distribution of patients had to be made according to the treatment

method used. Later, they were divided into two diagnostic groups (post-burn keloid scar sequelae, respectively post-burn hypertrophic scar sequelae) to find which treatment method was more frequently used depending on the type of scar. Thus, we observed that the most used and effective treatment method in both types of scar is the use of the local triangular crossed skin flap, from which 32.65% of patients (n=48) benefited.

Our results are consistent with the systematic review of free tissue transfers in burns by Shehab Jabir *et al.* in 2014 which included 30 studies conducted between 1984-2012 stating that free flaps can play an essential role in primary reconstruction as well as secondary reconstruction in burn patients. When used in primary reconstruction, they can significantly reduce the length of hospital stay, and the number of operations to achieve wound closure and, in some cases, even save limbs that would otherwise have to be amputated. When used in secondary reconstruction, they may be the only way to provide the necessary amounts of tissue to achieve sufficient release of the contracture, close chronic wounds, and treat unstable scars. This translates into reduced morbidity and improved functionality and aesthetics for patients (14).

Also, in our group of patients, 18.36% (n=27) benefited from a full-thickness skin graft. This type of plasty is most frequently used in acute skin burns with defects spanning a large surface area. There is no evidence that full-thickness skin grafting is clearly superior to split skin grafting for covering palmar burns according to the meta-analysis by Theddeus *et al.* in 2015. The current trend is to use FTSG as a wound dressing for hand burns in children because it is believed to have a lower rate

of secondary contracture and it could decrease the need for the secondary reconstructive procedure; however, FTSG has some limitations in its use. FTSG has limited donor sources, so it cannot be used to cover large burn areas. It also has a lower absorption rate compared to STSG due to edema and inflammation reactions. STSG also has some disadvantages, such as a higher rate of secondary contracture and a relatively lower aesthetic value. However, using STSG is advantageous in that it can cover a large area (15). It can also be combined with artificial dermis like Integra or Matriderm for a better functional result (16, 17, 18). The scientific literature states the existence of 3 methods of fixing the skin graft: stapler, cyanoacrylate adhesive, and tie-over dressing. The tie-over dressing is the traditional technique that no longer always provides satisfactory results in some areas of the body (19). Pediatric patients with post-burn cicatricial sequelae in which skin grafting was performed as a method of healing also benefited from VAC treatment because an improvement in the healing rate and a decrease in the wound infection rate was observed. This result is consistent with the randomized controlled trial conducted by Zheng XP *et al.* in 2019 in the Department of Burn Surgery of the First Affiliated Hospital of the University of Naval Medicine (20).

According to our results, 11.56% (n=17) of the patients benefited from tissue expansion with the help of an expander. Unlike other treatment techniques, such as skin grafting or the use of skin flaps, tissue expansion allows for a better match of skin color and texture (8, 21). The number of patients who have benefited from this method of skin plasty is reduced because following the presentation to the parents by

the attending physician of the available skin plasty methods, respectively their advantages and disadvantages, the parents were much more reluctant to choose the skin expander as a treatment method.

The conservative methods to prevent abnormal scarring, the long-term follow-up of the scars along with intense kinesitherapy are extremely important (22, 23). There is a possibility to treat the burn wounds in the acute phase and as well in the late reconstruction with skin substitutes, along with intermittent fat grafting of the scar (11, 24, 25).

CONCLUSIONS

Burns are a serious health problem, especially in low-income countries. They cause many deaths each year and are the leading cause of disability in many countries. Post-combustion contractures on extremities present a clinical challenge. Flexion contractures are more common than extension contractures. In mild contractures (defined simply as more than 50% of the range of motion of the joint is still possible), plastic surgical techniques, for example, the Z-plasty technique can be used to elongate the scar by transposition of the adjacent normal tissue. In more se-

vere cases, there is not enough adjacent tissue to allow contracture elongation and a different surgical approach is required. The most used and effective method of treatment in both types of post-burn scar sequelae is the use of the skin flap. This method is followed by scar excision and suture in the case of keloid scars, respectively by full-thickness skin graft plasty used in the case of hypertrophic scars.

Compared to skin grafts, flaps have the ability to expand to allow full extension of the affected region. Flaps are essential reconstructive modalities frequently used by plastic surgeons. As techniques evolve, many varieties of tissue transfer appear. A thorough understanding of the underlying principles, the ability to apply them to specific situations, and careful assessment of patient needs are necessary for the successful use of this tool. Recent advances in burn reconstruction offer methods to reduce scar tissue and joint contractures.

CONFLICT OF INTEREST AND FUNDING

The authors declare that there is no conflict of interest, and they received no specific funding regarding this scientific research.

REFERENCES

1. Bratu T, Crăiniceanu Z. *Plastic surgery, reconstructive microsurgery and burns*. Timisoara: Editura Victor Babeș, 2020, 62.
2. D'Souza AL, Nelson NG, McKenzie LB: Pediatric burn injuries treated in US emergency departments between 1990 and 2006. *Pediatrics* 2009; 124: 1424-1430
3. Kevin C. Chung, *Grabb and Smith's Plastic Surgery*, Wolters Kluwer, 2020, 684-700.
4. Powers JG, Higham C, Broussard K, Phillips TJ. Wound healing and treating wounds: chronic wound care and management. *J Am Acad Dermatol* 2016; 74: 607-625.
5. Prema Dhanraj, *Plastic Surgery Made Easy*. New Delhi: Jaypee Brothers Medical Publishers, 2006, 102-112.
6. Prohaska J, Cook C, *Skin grafting*. Stat Pearls, US National Library of Medicine, 2019.

Plastic surgical techniques for the treatment of burn abnormal scars in pediatric patients

7. Geoffrey C, Gurtner Peter C, Neligan D, Liu Z. *Plastic Surgery*, Fourth Edition, Elsevier, 2018, 214-314.
8. Martha F, Deepak MK, Khawaja GR. Tissue expansion reconstruction of head and neck burn injuries in pediatric patients-A systematic review. *J PRAS Open* 2018; 18: 78-97.
9. Bozkurt A, Groger A, O'Dey D, Vogeler F, Piatkowski A, Fuchs P. Retrospective analysis of tissue expansion in reconstructive burn surgery: evaluation of complication rates. *Burns* 2008; 34(8): 1113-1118.
10. Monroy MFDLC, Kalaskar DM, Rauf KG. Tissue expansion reconstruction of head and neck burn injuries in pediatric patients-a systematic review. *JPRAS* 2018; 18: 78-97.
11. Kavita SS, Ralston D, Giblin V, MacNeil S. Engineering of Accepted Skin-Equivalent Tissue for Tissue Repair: Current State and Perspectives. *Encyclopedia of Tissue Engineering and Regenerative Medicine* 2019, 285-298.
12. Stiefel D, Schiestl C, Meuli M. Integra Artificial Skin® for burn scar revision in adolescents and children. *Burns* 2010; 36(1): 114-120.
13. Pereima MJL, Feijó R, da Gama FO, de Oliveira Boccardi R. Treatment of burned children using dermal regeneration template with or without negative pressure. *Burns* 2019; 45(5): 1075-1080.
14. Shehab J, Quentin F, El-Muttardiab N, Dziewulskiab P. A systematic review of the applications of free tissue transfer in burns. *Burns* 2014; 40(6): 1059-1070.
15. Hur GY, Seo DK, Lee JW. Contracture of skin graft in human burns: effect of artificial dermis. *Burns* 2014; 40(8): 1497-1503.
16. Yamamoto Y, Fujihara H, Kirita M, Soejima K. Micronized dermal grafts (Rigenera™) and split-thickness skin grafts alone or in combination for deep dermal burn wounds. *Burns Open* 2022; 6(4): 212-217.
17. Nguyen DQ, Potokar TS, Price P. An objective long-term evaluation of Integra (a dermal skin substitute) and split-thickness skin grafts, in acute burns and reconstructive surgery. *Burns* 2010; 36(1): 23-28.
18. Theddeus OH, Prasetyono, Patricia M. Sadikin, Debby KASaputra, The use of split-thickness versus full-thickness skin graft to resurface volar aspect of pediatric burned hands: A systematic review. *Burns* 2015; 41(5): 890-906.
19. Chinmaya Chiranjibi Samal, Suvashis Dash, Karoon Agrawal, Raman Tandon, Comparative evaluation of three methods of skin graft fixation for split-thickness skin graft after release of post burn contracture of the neck. *Burns* 2019; 45(3): 691-698.
20. Zheng XP, Chen J, Chen TS, *et al.* Preliminary effect observation on the application of micro-negative pressure in children with small-area deep partial-thickness burn. *Chinese Journal of Burns* 2019; 35(10): 720-725.
21. 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* 2018; 44(3): 683-691.
22. Anthonissen M, Daly D, Janssens T, Van den Kerckhove E. The effects of conservative treatments on burn scars: a systematic review. *Burns* 2016; 42(3): 508-518.
23. Issler-Fisher AC. The importance of biomechanics and the kinetic chains of human movement in the development and treatment of burn scars-a narrative review with illustrative cases. *Burns* 2023; 49(3): 707-771.
24. Schiefer JL, Rath R, Ahrens E, *et al.* Evaluation of scar quality after treatment of superficial burns of the hands and face with Dressilk or Biobrane-An intra-individual comparison. *Burns* 2018; 44(2): 305-317.
25. Vana LPM, Battlerner CN, Ferreira MA, Caldini EG, Gemperli R, Alonso N. Comparative long-term study between two dermal regeneration templates for the reconstruction of burn scar contractures in humans: Clinical and histological results. *Burns* 2020; 46(3): 596-608.