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Treating Post-burn Cicatricial Deformities and Defects of the Cranial Vault with Local Plastic Surgery

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ABSTRACT

Aims This study aimed to describe a new method of plastic surgery for deformities of the cranial vault. The focus of the study was an analysis of the results of conventional and developed by authors techniques for the plastic surgery of post-burn scars and defects of the cranial vault.

Material & Methods The patients were divided into two groups: the main group, which used the newly developed method of plastic surgery (n=36), and the compared group – the conventional method of local plastic surgery (n=33). The investigation presented the surgical technique using a clinical case study.

Findings The authors developed a technique, which includes intraoperative balloon dermotension of the tissues surrounding the defect and an improved method of wound closure ("figure-of-eight suture").

Conclusion The advantages of the new technique are the relative simplicity of the procedure, the option of using local anesthesia, a low rate of postoperative complications, and a short postoperative period. In addition, the method used allows for good aesthetic results in the long term.

Keywords Intraoperative Period; Tissue Expansion Devices; Trauma; Alopecia; Tissue; Acantholysis

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Introduction

According to the World Health Organisation (WHO), burns are the third most common type of peacetime injury (accounting for 30% of all traumatic injuries) and have high rates of mortality and disability [1, 2]. In 2008, more than 410,000 burn injuries occurred in the United States, with approximately 40,000 requiring hospitalizations. In Europe, burn injury ranks 4th among all external causes of death and morbidity [3-5]. In Uzbekistan, more than 800,000 people per year are registered with thermal trauma [1]. The issue of burns treatment is acute in modern medical society and is highly relevant due to the large demand of the population for the treatment of burns. Among patients with thermal injuries, children account for 13.8 to 75.3% [6-8]. There is a growing number of studies on burn injuries; for example, the specificity of psychological and physiological complications in burn patients in Pakistan was studied by Ali and Ali [9]. More and more advanced rehabilitation methods are being developed [10]. In the process of developing new methods for the treatment of burn scars, a wide range of factors of a different spectrum is important, the specifics of which are the subject of this article.

The psychological consequences of trauma are also considered [11-14]. Scars in exposed areas of the body are perceived not only as a physical defect but also as an aesthetic flaw, which often leads to psychological trauma for the burn victim [15]. The sensitivity of the exposed areas of the body is the reason for the increased demands on the functional and aesthetic results of the treatment. When choosing the method of plastic replacement of a defect, most surgeons proceed from the following points: efficiency, minimal additional trauma, short duration, and technical simplicity [1]. For the plastic surgery of extensive soft tissue defects of the head, the following methods are mainly acceptable and effective: plastic surgery using preliminary balloon dermotension, provided there is healthy tissue adjacent to the defect, plastic surgery using flaps with axial blood flow (axial flaps), and microsurgical autotransplantation of complex flaps.

A key factor in the context of the treatment of burn injuries is the chosen technique. However, in addition to it, such important aspects as the psychological factor and postoperative support of the patient during the recovery process cannot be overlooked. It is important not to ignore such aspects and consider them together with the main treatment process due to the complexity of the issue of the full-fledged treatment of burns.

The purpose of the study was to optimize the results of surgical treatment of post-burn scar deformities and skull vault defects by developing a method of local tissue grafting and intraoperative expander dermotension.

Materials and Methods

The study was conducted on examples of surgical cases from the medical practice of the authors from 2000 to 2012. Cases of healing of head injuries caused by burn scars are given as examples. In the treatment, various methods were used, which are given in the results of the article.

To determine the criteria for selecting a method to replace post-burn scar deformities and defects of the cranial vault, the authors analyzed the results of using conventional and newly developed methods of plastic surgery in this category of patients. The patients were divided into two groups: the main group, which used the newly developed method of plastic surgery (n=36), and the compared group– the conventional method of local plastic surgery (n=33). Patients were grouped according to the type of plastic surgery, area, and nature of the defect. During the treatment, tissue samples were taken at different stages of treatment to study the glands, hair roots and the state of the tissue structure during the treatment.

Findings

The distribution of patients according to the area and depth of the defect and the type of plastic surgery is shown in Tables 1 and 2.

Table 1) Frequency of patients based on the area of defect and type of plastic surgery (numbers in parentheses are percentages)

Method of local plastic surgery	Small	Medium	Total
Conventional	23	10	33 (47.8)
Newly developed	25	11	36 (52.1)
Total	48 (69.6)	21 (30.4)	69 (100)

Table 2) Frequency of patients based on the depth of defect and type of plastic surgery (numbers in parentheses are percentages)

Method of local plastic surgery	Deep	Surface	Total
Conventional	6	27	29 (47.5)
Newly developed	11	25	32 (52.5)
Total	17 (24.6)	52 (75.4)	61 (100)

Patients with small scar abnormalities and cranial vault defects, with a frequency of 17 patients (24.6%), had deep defects. The distribution of patients in this group according to the location of the scar and defect is shown in Table 3. As can be seen, local plastic surgery was most often used for defects in the temporal area (39.1%).

Table 3) Frequency of patients according to the location of the lesion (numbers in parentheses are percentages)

Area of scarring and cranial vault defect	Method of local plastic surgery		
	Conventional (2nd group)	Newly developed (1st group)	Total
Frontal	3 (9.1)	5 (13.9)	8 (11.6)
Occipital	4 (12.1)	8 (22.2)	12 (17.4)
Temporal	16 (48.5)	11 (30.6)	27 (39.1)
Parietal	4 (12.1)	6 (16.7)	10 (14.5)
Combination of two or more areas	6 (18.2)	6 (16.7)	12 (17.4)
Total	33 (47.8)	36 (52.2)	69 (100)

33 (47.8%) patients were surgically treated using the conventional method of local plastic surgery for post-

burn scar deformation and cranial vault defect (comparison group). The basic concept is to excise the scar deformity ("alopecia") and suture the wound edges after mobilizing the aponeurotic layer.

Surgery technique

An incision is made at the border between the scar and the healthy skin. The scars are excised along the intermediate layer. The edges of the healthy tissue are sutured with stitches-holders. After careful hemostasis, the healthy dermal aponeurotic layer is mobilized 3-6 cm on both sides. The wound edges are connected with subdermal and dermal (double-row) interrupted sutures.

Clinical example

Patient B-v**.,** 2000; Medical history No. 1678/212; Date of injury: 2006; Diagnosis: Post-burn scar alopecia of the right and left temporal and occipital areas (Figure 1). Surgery No. 184 – Correction of post-burn scar alopecia by local surgery.

Figure 1) Patient B-v., 2000; Medical history No. 1678/212. A) Post-burn scar alopecia of the parietal area; B) Alopecia treated by local surgery, immediate plastic surgery result; C) Long-term plastic surgery result, one year after surgery

Of the 33 patients who underwent surgery by the conventional method, 26 (78.8%) showed uncomplicated healing of postoperative wounds. 7 patients (21.2%) experienced wound dehiscence: 5 dues to wound infection and 2 dues to tissue tension. After a course of conservative therapy, the wounds in these patients were closed with secondary sutures. Long-term results were assessed 1.5-2 years after surgery in 33 patients. The results were satisfactory in 28 cases (84.8%) and unsatisfactory in 5 cases (15.2%). Although the parameters of a scarred deformity or skull vault defect were suitable for local surgery, 6 (18.2%) out of 33 patients had a postoperative scar that had expanded to 2 cm at the time of follow-up examination, which significantly diminish the functional and aesthetic results of the operation. For this reason, the authors have developed a method of local plastic surgery that more effectively utilizes the surrounding tissue when treating post-burn scar deformities and defects of the cranial vault.

Developed methods of local plastic surgery (main group)

The developed method includes intraoperative balloon dermotension of the tissues surrounding the defect and improved wound closure ("octopus suture"). To develop a scheme for intraoperative balloon dermotension of the cranial vault soft tissues and to improve the surgical suture, an experimental study was carried out on 25 mongrel dogs.

Development of a scheme for intraoperative expander dermotension of the soft tissues of the cranial vault in an experiment

A rapid, cyclical skin stretching technique has been developed where flaps are mobilized to replace the defect. A Foley catheter was used as an expander. To develop an optimal scheme for rapid intraoperative tissue stretching, the following parameters were determined:

- The optimal volume and frequency of liquids to inject
- Expander pressure; duration (exposure) of stretching
- The duration of the break between cycles of liquid injection into the expander

Tissue oximetry ($P_{tc}O_2$), percutaneous thermometry (t °C), and measurements of pressure inside the Foley catheter during cyclic stretching of the cranial vault in dogs in different exposures (3, 4, 5 min) were performed for this purpose. A Foley catheter of optimal size Fr16 (32 ml) was used for stretching. Before, during, and after intraoperative balloon stretching, the dynamics of transcutaneous oxygen partial pressure in stretched tissues ($P_{tc}O_2$) were measured (Table 4).

Table 4) Mean tissue oximetry values ($P_{tc}O_2$) during cyclic stretching of the cranial vault skin in different exposures in dogs

Time		Tissue oxygenation index	
		Before	After
Duration of the inflated state of the cylinder tissue expander	3 min	124.3±0.44	20.7±0.85
	4 min	124.3±0.44	9.6±0.3
	5 min	124.3±0.44	5.4±0.17
Duration after withdrawal of the solution from the cylinder tissue expander	3 min	124.3±0.44	123.8±0.48
	4 min	124.3±0.44	120.6±0.39
	5 min	124.3±0.44	114.7±0.86

The initial level of $P_{tc}O_2$ was 124.3±0.44 mmHg. The initial temperature of the flap skin was 36.7±0.14. The most optimal exposure of the inflated state of the expander was 3 minutes. The optimal indicator of the duration of the break between stretching cycles was also 3 minutes. After implantation, the expander is filled with saline solution. During the fluid injection, the skin was being stretched.

Measurement of $P_{tc}O_2$ before stretching was carried out at two points: on healthy tissue and in the middle of the flap. The second measurement was taken after injection of the solution in the Foley catheter at the level of the inflated state of the expander. The third measurement was taken 5 minutes after the removal of fluid from the Foley catheter. Measurements were performed in all three cycles of intraoperative tissue stretching. Percutaneous thermometry was performed using an electronic thermometer Beurer FT 60 from Beurer GmbH (Table 5). The thermometry readings also determined the optimum stretching time (3 minutes) for the break time between cycles (3 minutes).

Table 5) Mean skin temperature (t^0C) during cyclic stretching of the soft tissues of the cranial vault in different exposures in dogs

Time		Skin temperature of the stretched flap	
		Before	After
Duration of the inflated state of the cylinder tissue expander	3 min	36.7±0.14	35.8±0.17
	4 min	36.7±0.14	34.1±0.16
	5 min	36.7±0.14	31.5±0.19
Duration after withdrawal of the solution from the cylinder tissue expander	3 min	36.7±0.14	36.9±0.18
	4 min	36.7±0.14	37.6±0.08
	5 min	36.7±0.14	32.2±0.3

Table 6) Mean intra-catheter pressure values (mmHg) during cyclic stretching of the cranial vault soft tissue in dogs

Time		Pressure inside the catheter
Duration of the inflated state of the cylinder tissue expander	3 min	360.1±0.56
	4 min	380.1±0.4
	5 min	390.0±0.4

Simultaneously with the injection of the fluid, the pressure inside the Foley catheter was measured using a pressure gauge. To connect the pressure gauge to the existing valve port of the Foley catheter, an additional Elema Sholander port has been used to measure the pressure inside the expander (Table 6). After planning, the flap was cyclically stretched. In the first stretching cycle, the volume of injected fluid should not exceed 1/6 of the volume of the Foley catheter. The pressure inside the Foley catheter was 360 mmHg. In the second stretching cycle, the volume of injected fluid should not exceed 1/4 of the volume of the Foley catheter. The pressure inside the Foley catheter is 380 mmHg. In the third stretching cycle, the volume of the injected liquid should not exceed 1/2 of the volume of the Foley catheter. At the same time, the pressure inside the Foley catheter is 390 mmHg. The injected liquid was heated to 42 °C to maximise vasodilation and improve microcirculation. The temperature of the stretched flap is 34 °C. After 4 minutes of stretching, the partial oxygen pressure in the tissues decreased to a critical level and amounted to 9.6±3.6 mmHg. Based on these data, it was possible to determine the optimal stretching time, which should not exceed 4 minutes. Then the saline solution was removed, and the tissues were allowed to relax until the normal $P_{tc}O_2$ index was restored. Within 3 minutes, the oxygen partial pressure level in the tissues returned to normal and amounted to 123.8±0.48. The flap temperature increased and amounted to 36.9±0.18. This was an indication of the next cycle of intraoperative tissue stretching. According to the data, the optimum interval between stretching cycles was 3 minutes for the soft tissues of the cranial vault. In controls, partial oxygen pressure and temperature in the stretched flap were measured after 25 minutes and at 1, 3, and 7 days postoperatively (Figure 2).

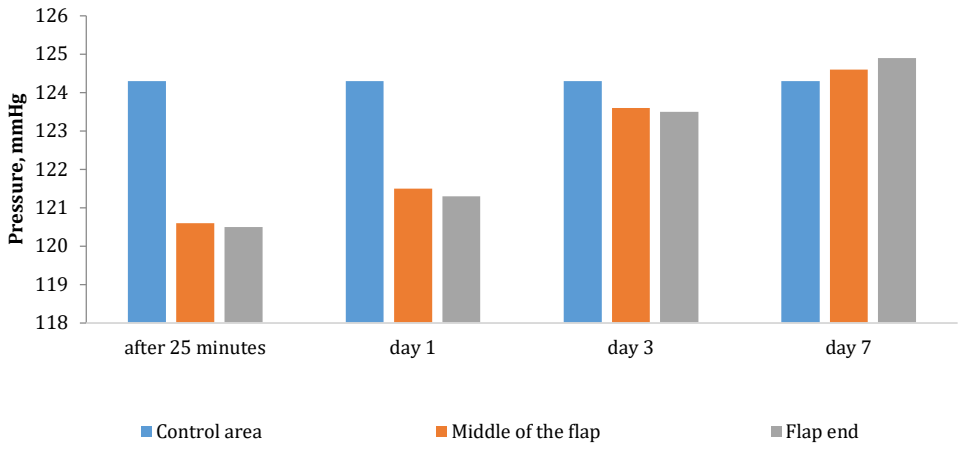

Figure 2) Oxygen partial pressure in the stretched flap after 25 minutes and on days 1, 3 and day 7 postoperatively

Accordingly, the values of partial O_2 pressure in the flaps indicate normal blood supply in all areas of the displaced flaps at the control times. This confirms the validity of the developed scheme of rapid intraoperative stretching of the tissues of the cranial vault area. Based on the results of this experimental

study, an optimal scheme for intraoperative balloon stretching of the cranial vault was developed: 3 stretching cycles of 4 minutes each, with a break of 5 minutes between each cycle ("3:4:5").

Morphological substantiation of the method of intraoperative expander dermotension

The validity of the experimentally developed scheme of intraoperative stretching of the cranial vault tissues was confirmed by the results of morphological studies of the stretched tissues taken from the patients intraoperatively at different stages of balloon dermotension. As a control, skin biopsy specimens from the cranial vault obtained during plastic surgery without intraoperative balloon stretching of the skin were used. In burn lesions of the skin of the cranial vault, the epidermis is thinning and, in some places, damaged, there is pronounced overgrowth of connective-tissue fibers in the dermis, with atrophy of the sebaceous and sweat glands (Figures 3 and 4).

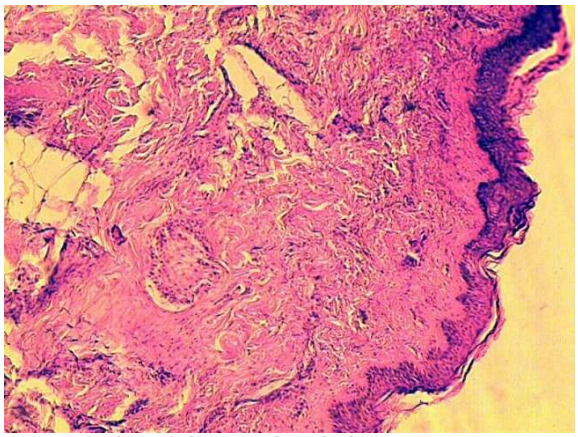

Figure 3) Skin of the cranial vault, burns, connective tissue overgrowth, 10×10

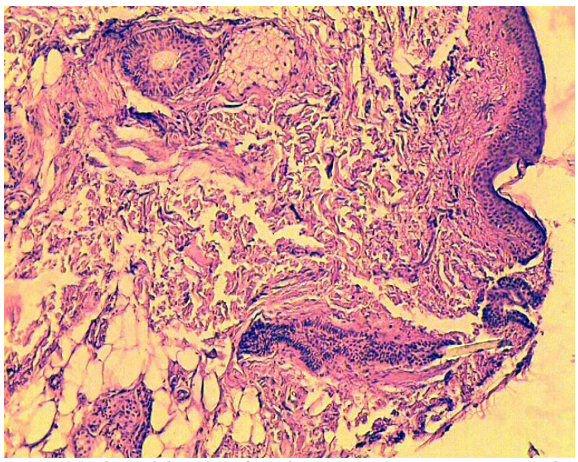

Figure 4) Skin of the cranial vault, connective tissue overgrowth, damage to the epidermis, 10×10

In addition to thickening and coarsening of the dermis fibres, there are infiltrative accumulations of connective tissue cells and the appearance of cell-free edema zones. Stretching the skin with balloon dermotension results in a noticeable uneven thickness of the epidermis, smoothing the papillary layer of the dermis, so that the number of rows of cells in the thorny layer is uniform. Their number is reduced to 3-4. In the early stages of dermotension, connective tissue overgrowth of the dermis and the structureless areas of oedema are preserved. In the longer terms of intraoperative balloon stretching, there is significant thickening in the dermis of the hair follicle walls, with the development of more hair shafts (Figure 5).

Figure 5) Hypertrophy of hair follicles. Increased number of hair shafts after balloon stretching, 10×40

This is accompanied by an overgrowth of connective tissue layers around the walls of the hair follicles (Figure 6). In the long-term follow-up of intraoperative balloon dermotension, significant thickening of all epidermal layers was observed. In the long-term follow-up of intraoperative balloon dermotension, significant thickening of all epidermal layers takes place. This is accompanied by an increase in the volume proportion of microvessels in the dermis and the normalization of its structure, which is reflected in the restructuring of the fiber components that become thinner and less chaotic in their arrangement. However, the papillary layer of the dermis remains smooth.

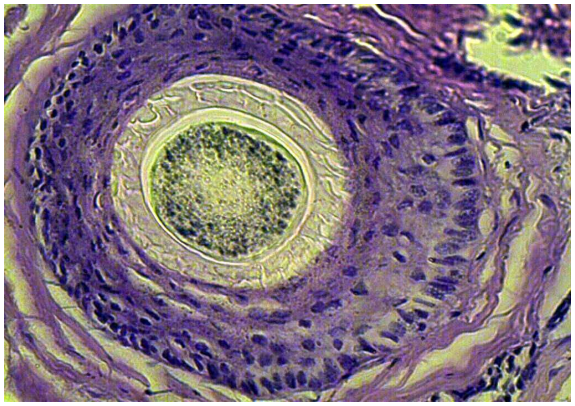

Figure 6) Hypertrophy of the hair follicle after intraoperative balloon stretching, 10×40

Thus, stretching of the skin leads to the loss of the dermal papillary layer, which is not restored in the long-term observation period. There is no disruption of the epidermal skin of the cranial vault (Figure 7).

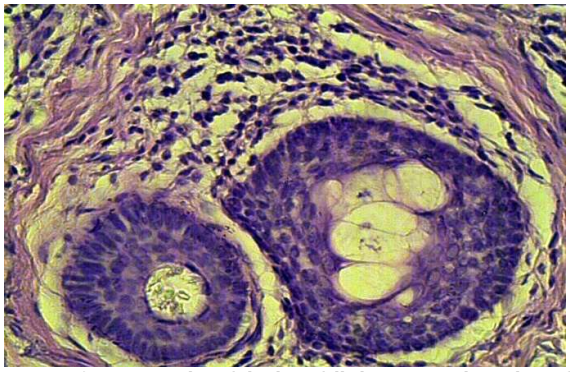

Figure 7) Hypertrophy of the hair follicle, increased number of hair shafts after intraoperative balloon stretching, 10×40

No acantholysis of the thorny layer was detected. The dermis integrity is intact. There are no tears in its fibers or disruption of vascular integrity. There are no hemorrhages in the dermis (Figure 8).

Figure 8) Hypertrophy of the hair follicle, increased number of hair shafts after intraoperative balloon stretching, 10×40

Areas of hemorrhage are found only in the hypoderm, among the layers of adipose tissue cells. At the same time, there was no rupture of the blood vessel walls (Figure 9).

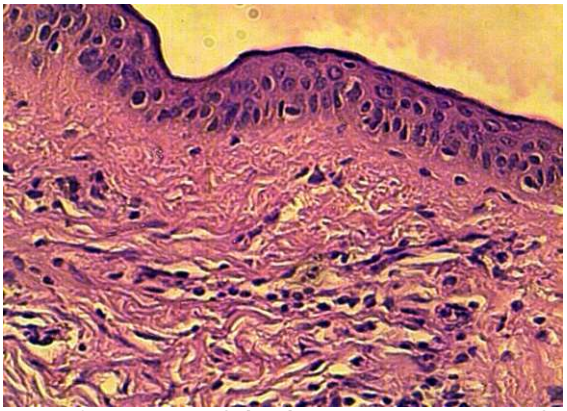

Figure 9) Restoration of the skin structure 30 minutes after intraoperative balloon stretching, 10×40

Thus morphological studies showed that intraoperative stretching of the skin according to the scheme developed by the authors in the experiment does not cause disturbances in its general architectonics. The epidermis does not show any damage to its integrity in the form of tears or cracks. There is a reduction in the number of rows of cells in the thorny layer. No acantholysis or cytolysis phenomena were observed. The authors have identified a rather specific reaction of the burned skin of the cranial vault to its expander dermotension. This reaction consists of a significant increase in the number of hair shafts in the hair follicles, which is accompanied by a thickening of the walls of the follicle.

Intraoperative tissue stretching of the cranial vault using the clinic method (clinical material)

The analysis of the results of experimental and morphological studies allowed the authors to develop an optimal scheme for rapid intraoperative stretching of the cranial vault tissues.

The technique of intraoperative stretching of the cranial vault tissues according to the clinic method

An incision is made at the border of the scarring mass and the healthy skin. A hypodermic pocket is formed through this incision using the tip of Gross-Maier dressing forceps, sized for the Foley catheter. The Foley catheter is implanted in the formed pocket. The wound is temporarily sutured with nodular sutures. The volume of liquid injected into the expander is calculated from the Foley catheter number. The expander will be filled until the tissue turns pale and becomes tense.

Three stretching cycles are carried out according to the developed scheme. The bloated state of the expander is maintained for 4 minutes, then the physiological solution is drained, and the tissues are allowed to "rest" for 5 minutes. After that, considering the available tissue reserve, the scars are excised, and the resulting wound is closed intraoperatively with stretched tissue [1].

Method of suturing a cranial vault wound

Depending on the area of scar deformation, the problem of tension of the wound edges and the subsequent formation of wide scar areas of alopecia remains unresolved. As a result, a method of suturing the wound edges after tissue distension has been experimentally developed and introduced into clinical practice by the authors.

Suturing technique

Given the structural features of the periosteum, the surgical suture material should be monofilament, synthetic, and non-absorbable. Before suturing, the edges of the wound must be previously aligned and a guideline drawn on the periosteum. The distance between the edge of the wound and the injection should not exceed 3-4 mm. The first injection is made into the skin and subcutaneous tissue. A second injection is then made into the opposite periosteum at a distance of 2 mm from the guide lines, and then a third injection is made into the periosteum on the side opposite the second injection. Then again, an injection is made into the subcutaneous and dermal areas on the opposite side. There is no subcutaneous space for drainage (Figure 10).

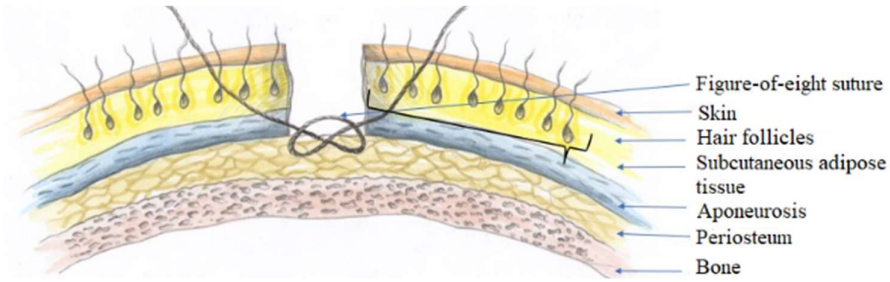

Figure 10) Figure-of-8 suture technique

Clinical case study: Patient D-v., 2012; Medical history No. 958/218; Date of injury: 2013; Diagnosis: Post-burn cicatricial alopecia of the parieto-occipital areas (Figure 11). Surgery No. 211 - Removal of post-burn scar alopecia by intraoperative tissue stretching.

Figure 11) Patient D-v., 2012. Case history No. 958/218. A) Post-burn scar alopecia of the parieto-occipital areas; B) Intraoperative tissue stretching with the Foley catheter; C) Long-term result of plastic surgery, 1.5 years after surgery

Clinical case study

Patient K-v., 2004: Medical history No. 8056/1520: Date of injury: 2006; Diagnosis: Post-burn scar alopecia of the occipital area (Figure 12). Surgery No. 273 – Removal of post-burn scar alopecia by intraoperative tissue stretching and "figure-of-eight suture".

Using the developed method

35 (97.2%) patients had no complications in the immediate postoperative period. 1 (2.8%) patient had a complication in the form of infection of the wound. Long-term results were studied 1.5-2 years after plastic surgery. 34 (94.4%) out of 36 patients were examined. The results were found to be good in 17 (50%) patients. Satisfactory results were observed in 13 (38.2%) patients. In 4 (11.8%) patients, there was an expansion of the postoperative scar to 2-3 mm, which significantly worsened the aesthetic results.

Figure 12) Patient K-v., 2004. Case history No. 8056/1520. A) Post-burn scar alopecia of the occipital area; B) Immediate result of plastic surgery, day 21; C) Long-term result of plastic surgery, 1.5 years after surgery.

Comparative analysis of the results of local plastic surgery of post-burn scar deformities and defects of the cranial vault

An analysis of the results of patients with post-burn scarring and cranial vault defects showed that a total of 17 (25%) out of 68 patients had various complications. Most of them were associated with infection of the wound (Table 7). The immediate effects of local plastic surgery with an assessment of the final result were studied in all patients.

Table 7) Frequency of various complications depending on the type of plastic surgery (numbers in parentheses are percentages)

Indicator	Comparison group	Main group	Total
Complications	12 (36.4)	5 (14.3)	17
Wound infections	5 (41.7)	1 (20)	6
Wound dehiscence due to tension	7 (58.3)	4 (80)	11
Number of patients	33	35	68

In 68 (98.6%) of 69 patients, the results were positive in 51 (75%), and negative in 17 (25%). Therefore, to optimise the indications for a particular type of plastic surgery and to determine the limits of conventional and developed techniques, the authors analysed the immediate and long-term results of post-burn scar plastic surgery on the cranial vault (Table 8).

Table 8) Frequency of the immediate results of the surgery based on the area of the defect (numbers in parentheses are percentages.)

Area of scar defect	Positive		Negative		Total
	Comparison	Main	Comparison	Main	
Small	19 (82.6)	23 (95.8)	4 (17.4)	1 (4.2)	47 (69.1)
Medium	2 (20)	7 (63.6)	8 (80)	4 (36.4)	21 (30.9)
Total	21 (63.6)	30 (85.7)	12 (36.4)	5 (14.3)	69 (100)

As can be seen in the table, application of the developed method of local surgery with an advanced stitch formation gave positive results in 30 (85.7%) out of 35 patients in the main group, whereas in the compared group, positive results were obtained in 21 (63.6%) out of 33 operated patients.

There were 17 patients with deep scar defects of the cranial vault in the study group. The developed method of plastic surgery was used on 11 of them, and 9 patients (81.8%) had a positive result. In the compared group, the conventional technique of treating deep defects yielded positive results in only 3 of 6 patients (50%) (Table 9).

Table 9) Frequency of the immediate results of the surgery based on the depth of the scarring of the cranial vault (numbers in parentheses are percentages)

Scar defect	Positive		Negative		Total
	Comparison	Main	Comparison	Main	
Surface	18 (66.7)	21 (87.5)	9 (33.7)	3 (12.5)	51 (75.4)
Deep	3 (50)	9 (81.8)	3 (50)	2 (18.2)	17 (24.6)
Total	21 (63.6)	30 (85.7)	12 (36.4)	5 (14.3)	68 (100)

The long-term results of using the conventional and the developed methods of treating scars on the cranial vault, along with the immediate results, were affected by the area and depth of the deformity. The long-term results in the compared groups are presented in Table 10.

Table 10) Frequency of long-term results of conventional plastic surgery methods depending on the type of surgery (numbers in parentheses are percentages)

Surgery method	Long-term result			Total
	Good	Satisfactory	Unsatisfactory	
Conventional	6 (18.2)	16 (48.5)	12 (36.4)	33 (48)
Newly developed	11 (31.4)	19 (54.3)	5 (14.3)	35 (51.5)
Total	17 (24.6)	35 (50.6)	17 (24.6)	68 (100)

As can be seen, good and satisfactory results were observed with the developed methods of plastic surgery. Analysis of the effects showed that local tissue grafting can be used to cover small and medium-sized defects in the cranial vault, specifically in the frontal and parietal areas. However, a reserve of surrounding unaffected tissue, the absence of infection, and the presence of a well-circulated subcutaneous layer or granulation tissue are prerequisites.

Discussion

Wang *et al*. [16] studied the effect of the technique of synchronously perforating and transplanting hair follicular-units in the treatment of cicatricial alopecia after burn. They resumed, that the technique of synchronous perforation and hair transplantation from the follicular unit is safe and effective, with less surgical trauma and allergies. The hairs implanted with this technique grow well and become longer in the alopecia scar area.

Surgical management of hair loss has become an increasingly challenging procedure when dealing with scar alopecia, Noori *et al*. say [17]. In the head and neck scar alopecia case, they selected hair transplantation based on the type and depth of the scar. Follicular unit extraction was performed when large grafts were not required, including beard, mustache, and eyebrows, while follicle isolation was used when extensive scarring was present on the scalp.

According to Wang *et al*. [18], burns are the most traumatic and physically debilitating injuries that affect nearly every organ system and cause significant morbidity and mortality. Early burn excision and skin grafting are common clinical practices that significantly improve outcomes for severely burn patients, reducing mortality and hospital days. However, slow wound healing, infection, pain, and hypertrophic scarring remain major challenges in burn research and treatment. Their article reviews and discusses the problems of contemporary burns treatment, breakthroughs, and innovative strategies developed over the past decade, which have improved burn management, as well as pioneering ideas in burn research to improve burn wound, with a focus on burn infection, pain management, wound healing, and skin tissue engineering.

A large number of contemporary studies focus specifically on the aesthetic side of the issue [19-25]. Agaoglu *et al*. [19] conclude that hair transplantation is a promising treatment for post burn alopecia after combined non-ablative fractional laser and microfat injection. Hua and Wei [20] argue that fat grafting plays a key role in hair survival and are interested in the use of cryopreserved fat as its use may make re-applying fat grafting unnecessary and would like to know more, such as whether a protective fluid needs to be used during cryopreservation of microfats.

Physical and psychological problems that occur in patients who have suffered deep burns on exposed areas of the body dramatically, reduce their quality of life [21, 26-30]. Mordyakov [21] studied the frequency and

structure of postoperative complications in patients with third-degree burns in the treatment of donor site wounds with moisture-saving film dressings. He concludes that the usage of dressings and lymphotropic therapy in the treatment of wounds of donor sites in patients with deep burns determines the morphological picture healing on the 4th-5th day after the operation, the appearance of additional hair sheaths, the predominance of regeneration processes, which ensures the prevention of the occurrence of dry scab, reduces the inflammatory process, favors the formation normotrophic scars [31, 32].

Aguilera-Sáez *et al*. [22] conclude that the scientific evidence for the use of ESWT (Extracorporeal Shock Wave Therapy) in the treatment of burn patients is weak due to the limited number of studies and their quality. However, ESWT appears to be an effective tool in this area, and further clinical trials are needed [33].

Rowan *et al*. [23] reviewed the recent advancements in the care of burn patients with a focus on the pathophysiology and treatment of burn wounds. They noted that burns are complex and can present unique challenges that require late intervention or lifelong rehabilitation. In addition to improvements in stabilization and patient care, burn care research has led to advances that will continue to improve functional recovery [34-37].

Wainwright [24] discussed the clinical application of these procedures with examples of treatment of specific problems commonly encountered by the reconstructive surgeon. She says many patients continue to experience problems long after their burns have healed. Contractures and deformities are common consequences of a scar resulting from thermal injury [38, 39]. There are many techniques available to the burn reconstruction surgeon, ranging from simple graft techniques to complex grafts of free tissue.

According to MacLennan *et al*. [25], head and neck burn reconstruction is best accomplished with a combination of skin grafts, local flaps and random free flaps, and tissue expansion. Caution should be exercised in some patients with head and neck burns, and in many patients with alopecia areata, tissue expansion can provide excellent functional and cosmetic results with minimal donor site sensitivity [40].

The limitation of this study is the sample size in the context of treating different areas of scarring and cranial vault defect. In future studies, the authors plan to describe in more detail the specifics of treating particular areas of scarring, such as frontal, occipital and parietal.

Conclusion

A comparative analysis of the results of local plastic surgery on post-burn scar defects and deformities (alopecia) of the cranial vault shows the efficacy of the developed method of intraoperative rapid balloon tissue stretching in small and medium-sized linearly shaped scarred deformities of the cranial vault, not engaging the deep-lying structures. Moreover, the advantages of the method include the relative simplicity of the procedure, the option of using local anesthesia, a low rate of postoperative complications, and a short postoperative period. After local surgery using the conventional method, in more than 14% of cases, postoperative scars are enlarged, and hypertrophic scars develop.

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