Sergey Bogdanov

COMBUSTIOLOGY AND SKIN AUTOPLASTY

Ministry of Health of Russian Federation

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Federal State Budgetary Educational Institution of Higher Education
"Kuban State Medical University"

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Sergey Bogdanov

Under the editorship of
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This monograph is a summary of indications and techniques of skin autoplastic surgeries, current issues of surgical treatment of burn victims. It represents the long-term experience of Kuban combustiologists. The work also describes necessary conditions for the survival of a full-thickness skin autograft on the granulating wound. Significant attention is devoted to the development of a new skin autoplasty technique using one full-thickness autograft in patients with total deep burns and total scar deformities of the face. A variety of clinical cases illustrates different types of surgical treatment, both staged and early including dermabrasion. We also describe conditions for early necrectomy with primary plasty. The development of new methods for vacuum therapy in combustiology and improvement of auto- and allofibroblasts usage in different autoplastic surgeries are also widely covered.

The book is recommended by the Academic Board of Federal State Budgetary Institution “Turner Scientific Research Institute for children's Orthopedics”, Ministry of Health of Russia, protocol No1 from the 12th of February, 2019. It also is recommended by “Kuban State Medical University”, protocol No 6 from the 21 of February, 2019.

This monograph is prepared in accordance with clinical recommendations of Russian Public Organization “Association of combustiologists “World without Burns”.

The book contains 7 chapters, 368 pages, 601 illustrations.

There are engraving from the books “The history of the composition of the human body” and “The anatomy of the human body” by Juan Valverde de Amusko (1556-1560) and illustration “Prometheus Brings Fire” by Heinrich Friedrich Fügeris (1817) on the cover page.

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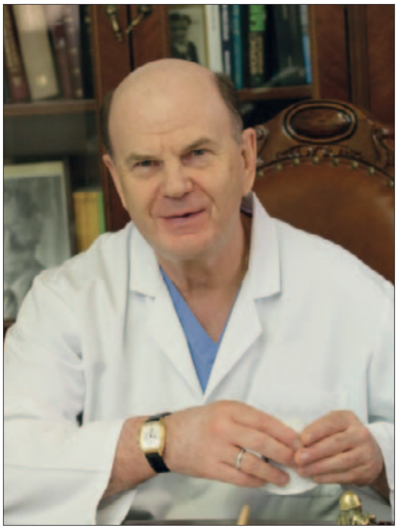
CONTENT

WELCOMING REMARKS



Any surgeon must know main types of skin autopalsty. This seems in particular relevant for emergency surgery and traumatology because there's no time to think and some wounds should be closed promptly. Combustiologists are the most experienced autoplastic surgeons, they are able to perform not only all types of free autoplasty using split-thickness skin autografts, but also different types of plasty using adipo-cuataneous flaps. Russian and Soviet surgeons have contributed significantly to the development of plastic surgery. They introduced new types of skin autoplasty named after them. V.K. Krasovitov, who was my teacher and countryman, is world famous for his surgical technique. His method is used within the first hours after traumatic detachment of the skin. I am pleased that Kuban surgeons are still developing new types of skin autoplasty. These methods are widely described in this work. All clinical cases from this work were performed by surgeons of Research and Development Institution – S.V. Ochapovsky Regional Clinical Hospital No1 in Krasnodar region. In this work the author amply presented his clinical experience using expressive illustrations and observations.

I am sure this work will draw attention of students, post-graduate students and surgeons of different specialities

Vladimir A. Porkhanov
MD, PhD, academician of RAMS,
Hero of Labour of the Russian Federation,
laureate of the Government of the Russian Federation Prize,
laureate of Prizvanie award,
Winner of the State Prize of the Russian Federation
Honored doctor of the Russian Federation,
Chief Doctor, Research and Development Institute – S.V. Ochapovsky Krasnodar Clinical Hospital No1

Burn trauma is one of the most complicated and severe issues in modern medicine. Combustiology is a narrow field of surgery and traumatology, however, requiring specialists to have proficiency in traumatology, surgery, resuscitation, transfusiology and other areas.

Because there is one burn center in Krasnodar region, initially patients with burn trauma are admitted to trauma and surgical departments requiring regional doctors to have knowledge of combustiology.

The main type of surgical treatment in combustiology is skin transplantation. The monograph represents all types of skin autoplasty. I am pleased that Kuban is still developing new methods of surgical treatment, improving cell therapy in combustiology, practicing new surgical techniques. These methods are widely covered in this monograph.

I am very pleased that combustiologic school of Kuban is one of the leading schools in Russia and among leading positions in the world. Nowadays, the scientific school of Kuban combustiology is developing on the basis of Kuban State Medical University.

The author amply demonstrates his clinical experience using distinctive illustrations and observations.

This work attracts the attention not only students, postgraduate students, surgeons of different specializations but also teachers of medical institutions.

Evgeniy F. Philippov,
MD, Minister of Health of Krasnodar Region

Closure of wounds with different etiology is part and parcel of surgery and traumatology. Some types of autoplasty using local tissues are known BC. 150 years ago, in 1869, Jacques Reverdin performed the first free skin transplantation, which has been being improved till present. In our Medical University the Chief of the Surgery and Topographic Anatomy Department Vladimir K. Krasovitov developed the unique worldwide recognized technique of full-thickness skin autografting. Currently, surgeons of Kuban State Medical University improve existing techniques and implement new ways of skin autoplasty, as this book demonstrates. This book is a long-waited work containing all types of skin autoplasty both free and non-free. Moreover, this work includes biographies of Russian and Soviet surgeons who contributed greatly to the development of new types of skin plasty which are the basis for modern plastic surgeries and have great practical significance.

This monograph summarizes long-term scientific studies and clinical trials performed on the basis of Kuban State Medical University and Scientific and Research Institution – S.V. Ochapovsky Regional Clinical Hospital No1 of Krasnodar region. This work is fundamental and it will be informative for students, senior students and post-graduate students

Sergey N. Alekseenko
MD, Chancellor of Kuban State Medical University

INTRODUCTION

“Combustiologist is a painter who draws his work on a human body, however, he has only one chance to show his creative skill, and the chief censor of his work is his patient… ”

Any wound should be closed using plastic surgery. A surgeon must reconstruct a wound defect using different methods in conformity with main principles of skin plasty. This work contains main types of skin autoplasty performed in Kuban school of combustiology and plastic surgery.

Currently, any information can be found on the Internet; however, there are a lot of sketchy information without a review of a particular type of indications for skin plasty there. In our opinion, performing skin plasty, surgeons of all specialties should use the universal classification and terminology.

A desk book of any surgeon making skin plasty should be a book by an outstanding Hungarian surgeon Yanosh Zoltan “Skin transplantation”, published in the 80s years of the 20th century. This two-volume book contains detailed historical information about all types of skin autoplasty known by that time. This work has black and white illustrations, but it does not diminish its current relevance and visibility. Unfortunately, this edition was not republished, and existing copies are personally handed from one person to another.

Skin reconstruction by means of autoplasty with pedicle flaps was known many years BC in Ancient Egypt and India – to restore nose defects. A. Celsus is famous for his description of skin autoplasty. G.Tagliacozzi published his principal work on plastic surgery where he described transplantation of a skin flap raised from upper extremities to reconstruct chopped-off parts of the face, in particular for nasal reconstruction in Bologna in 1597. One of the first Russian fundamental works was a monograph “Operations on the surface of the human body” by Yu.K. Shimanovsky published in 1865.

Plastic surgeries with local tissues developed by such plastic surgeons as Ammon (1848), Burom (1838), Pick (1949), Yu.K. Shimanovsky (1865, 1870), A.A. Limberg (1967), R.C. Websten (1978), Celsus (1859), Dieffenbach (1882), Guerin (1880) and many others are widely known. In practical work surgeons call plasty after its authors or type of elevated adipo-cutaneous flaps: rhomboid, trapezius, V-Y- plasty etc. In 1946, in his study “Mathematical principles of local plastic procedures on the surface of the human body” A.A. Limberg mathematically justified plasty with converging rhomboid flaps (Z-plasty). There he gathered historical information about different plastic surgeries performed by other surgeons: Horner (1837), Denonvilliers (1854), Berger (1904), McCurdy (1913), Morestin (1914), Matthews (1915), J. S. Davis (1924), Joseph (1931). Theoretically, these surgeries are based on displacement of pedicled geometric flaps. Intact blood supply within a skin flap, which depends on length and width of a pedicle and localization of adipo-cuateneous flaps, is also considered essential. Moreover, Indian plasty relates to plastic surgery using local tissues with regular pedicle.

Plasty using pedicle flaps from distant parts gets it origin from Italian plasty. Plasty using a tube flap introduced by V.P. Filatov in 1916 also relates to plasty with pedicle flaps.

24.11.1869 Jacques Reverdin performed the first free skin transplantation (3 x 4 mm) on the granulating wound in Guyon (France). He reported about it for the first time in Paris 08.12.1869. In 1870, such types of surgeries were performed in England by Pollock, in Vein by Billroth, in Russia by S.M. Yanovich-Chainsky in the Surgical Department of Nikolaevsky Hospital in Saint-Petersburg. Russian surgeons P.Ya. Pyasetsky (1870), A.O. Yatsenko (1871) and others modified free skin plasty. In 1874, professor Tiersch from Leipzig University transplanted skin with a thickness of 0,2-0,25 mm and more than 1 cm in diameter and harvested split dermis using a scalpel. Since then, many types of free skin transplantation for wounds of different genesis were designed.

A free full-thickness skin autograft is worldwide recognized to have better qualities than a split-thickness autograft. Reverdin's student surgeon Yu.Yu.Dzganelidze wrote: "Thin transplants have following benefits: donor site heals fast, easy to harvest big sizes, it almost always survives. Drawbacks of split-thickness skin grafts are: poor esthetics, they contract, in some areas enable to defend underlining tissues. Full-thickness autografts have following benefits: they give better cosmetic results than split-thickness autografts, look similar to healthy skin, demonstrate minimal tendency to contraction, full-thickness skin defend underlining tissues. The main drawback of full-thickness autotransplants is low chances to survive on the granulating surface".

Full-thickness autografts demonstrate good survival in clean conditions. V.M. Krasovitov's plasty (within the first day after traumatic detachment of the skin) and B.V. Parin's (in reconstructive surgery)plasty with such grafts are widely used. Conditions limiting full-thickness graft survival are as follows: fat tissue, infection, decreased blood flow to the wound bed.

In combustiology, if lack of donor sites occurs after necrectomy, the wound surface is closed with perforated autotransplants with different indexes of perforation and stretching (1:2; 1:3; 1:4; 1:6) to increase a graft size. This procedure is justified for patients with severe thermal burns. However, according to many authors, even if there is a lack of donor areas on functional place, such as face, neck, hands, feet and other major joints, plasty without perforation is indicated.

Dutch surgeon Lanz, who designed an instrument for graft perforation, was among pioneers of perforated autografts (1908). In 1930, B. Douglas and in 1937 L. Dragstedt and H. Wilson suggested plasty using skin flaps with holes, whereby perforation holes 1-1,5 cm in size were made in chequered fashion using a scalpel. Soviet professor B.V. Parin was the first who suggested the term "perforated flap".

The best survival demonstrate skin autografts transplanted to granulations, muscle tissue, fascia, mosaic areas of close-meshed subcutaneous adipose tissue and left deep layers of dermis after exposure. Grafts survive worse on fat, tendons, bone tissue possibly due to poorly vascularized wound bed. Autografting of split-thickness (0,3-0,5 mm) transplants due to less tendency to scarring and retraction in long-term period gives better cosmetic results. Therefore, they are used to reconstruct functionally important parts of the body such as face, hands, feet and joints.

Reasons to write this fundamental work were as follows: to summarize clinical experience of both combustiologists and also other medical workers of S.V. Ochapovsky Regional Clinical Hospital, review new methods of skin autopalsty, present clinical cases of wound closure of different genesis, pay tribute to pioneers of the Russian school of plastic surgery.

Treatment of patients with thermal trauma still remains challenging in modern medicine. According to WHO burns are the third, in some countries the second, most common injury. In Russia annually 420-450 thousand patients with thermal injuries seek medical care. 120 thousand are admitted to the specialized surgical, burn and trauma departments. Up to 40% of patients are children.

Up-to-date concept of deep burns management is early surgical treatment that allows reducing severity or/and preventing the progress of burn disease. It also boosts skin recovery. Early necrectomy with primary plasty provides early rehabilitation of patients because it gives better cosmetic results and decreases risk of scar tissue formation in contrast to plasty on the granulating wound.

Deep local burns are observed in 60-75% of patients registered with a thermal wound. Among other anatomical structures local burns are typically observed on opisthenar – 44%, so post-burn scar deformities of hand usually cause invalidization. Therefore, special attention should be drawn to the development of new methods of management of burned hands in acute period.

Management of deep facial burns remains one of the most challenging problems in combustiology and reconstructive plastic surgery, due to the great importance of the face both esthetically and functionally. Deep facial burns are difficult to deal with and they often cause functional impairment. Facial scars are not only physical defects, but also psychological trauma. Surgical aspects of facial autoplasty in acute and delayed periods of burn trauma have not still been resolved and are the focus of research.

Superficial skin burns are prevailing among other burns. In 80% of cases patients with such burns do not have large defects and they are treated conservatively, whereas in 70% of cases – on an out-patient basis. 60-80% of hospitalized patients with burns (approximately 30% of all burned patients) also have superficial skin and boundary burns.

Modernization of healthcare system in the last 10 years allows improving the quality of medical care for people. However, in combustiology a number of questions remain unanswered. According to specialized medical burn departments of Russia adult mortality was 6,1% in 2017, children mortality - 0,3%. Children mortality remains stable at 0,4-0,8% in recent years.

Not only large, but also local burns present difficulties in management of children burns. This is related to anatomo-physiological features of a child's organism and imperfection of defensive and regulatory mechanisms. Nondifferentiation of nervous and other systems of a child's organism prevents the adequate management of burn injuries. This fact seriously influences the results of treatment.

This work represents clinical cases of not only standard skin plasty, but also original methods of skin reconstructions which represent an alternative to other types of surgical treatment. I hope the monograph will be informative for students and postgraduate students, and also generate professional interest among practical surgeons.

CURRENT ISSUES IN CLASSIFICATION OF SKIN AUTOPLASTY

Historically, many types of skin autoplasty and classifications have been developed. Unfortunately, modern plastic surgery and combustiology differ in terminology and classification. Frequently, the same type of plastic surgery is called by some surgeons “flap palsty” and “transplant plasty” by others. For the unity of classification, in 2015 the Society of Russian Combustiologists “Life without burns” developed clinical recommendations of the surgical treatment of patients with burns. These recommendations are presented on the official web-site of Russian combustiologists www.combustiolog.ru. They contain a classification of skin autoplasty. A basic principle of their differentiation is free and non-free skin autoplasty. Completely excised skin area is commonly referred to as an autotransplant (or autograft) – free plastic. And skin area with a pedicle is called a flap, and it requires non-free skin autoplasty. Surgical methods of skin reconstruction include the following:

1. Free skin plasty

a) Autodermotransplant, includes only skin (non-vascularized):
— split-thickness
— full-thickness

b) Composite autotransplant on microvascular anastomosis (vascularized):
— adipo-cutaneous
— fascio-cutaneous
— Musculo-cutaneous with a bone fragment

2. Non-free skin plasty

a) Using local tissues with additional incisions and without them including gradual tissue expansion (dermatension). Dermatension can be acute and chronic, also using expanders.

b) Distant flap grafting (island, flat or tube) on regular or temporal pedicle:
— adipo-cutaneous
— fascio-cutaneous
— Fascio-cutaneous with a bone fragment

Skin plasty can be performed immediately after surgical prepare of a wound of any genesis (simultaneous skin plasty) or can be delayed (delayed skin plasty). Skin plasty on a granulating wound is performed when the wound the bed is ready (there are bright, fine-grit granulations with poor wound fluid and optimal time of readiness). The main way of skin repair of deep skin defects is autodermoplasty using a split-thickness autograft harvested with a dermatome. An optimal thickness of a split autograft is 0,2-0,4 mm. Transplantation of non-perforated split-thickness skin grafts gives the most favorable technical and esthetical results. Free autodermotransplants should be placed on a wound transverse to the axis of the surgical area. Limited deep skin defects in functionally and esthetically important zones with special localizations (head, face, hands, genital organs, neck and major vessels) and also with open deep structures (joints, vessels, nerve trunks, bones, tendons) reconstructive plastic surgery should be used in early period – plasty of defects with soft tissues including dermatension, full-thickness skin autograft, composite autografts on microvascular anastomosis or flaps on regular or temporal pedicle. The donor defect after graft and flap harvesting should be closed using plastic surgery with local tissues or transplantation of split-thickness autodermotransplants. Major deep skin defects with lack of donor resources the following methods and techniques of plastic closure of wound defects are used: split-thickness perforated autodermotransplant – engraving of skin graft using a special device (perforator) in order to increase the area of a graft. Split-thickness perforated autodermatransplants on functionally and esthetically important zones can be used only in case of critic deficit of donor resources.

CHAPTER 1
FREE SKIN AUTOLASTY

In combustiology free split-thickness autografting is the most commonly used surgical treatment, when autografts are taken by a dermatome. The main goal of autoplasty in patients with burn injury is to get not only positive functional, but also esthetic results that meet patient's needs. If burn has a limited size and there is no lack of skin resources, even one surgery may be enough to restore the skin. In case of heavy burns there is a lack of donor resources and one surgery is not enough for dissection and closure of large skin damages.

The optimal technique is to change the wounded defect with a skin autograft immediately after dissection of dead tissues in order to minimize the pathologic influence of the forming wound. The types of skin reconstruction after surgical removal of eschar differ and depend on surgical strategy, donor skin resources and availability of wound dressings. Transplant survival after the first plasty and necrectomy depends both on the overall patient's health and wound condition after excision. Unfavorable "local" factors are as follows: bare subcutaneous tissue and tendons; insufficient hemostasis leading to hematomas, insufficient removal of dead tissues and finally the delayed surgery after the burn injury causing wound inflammation.

In 1939 English surgeon Padgett and engineer Hood created a dermatome that was a boon for the development and improvement of free skin plasty and surgical excision of burn wounds. The first USSR dermatome was created in 1947 by M.V. Kolokoltsev. Kolokoltsev's dermatome with tangential knife motion is used to take split autografts of different thickness and excise the wound in layers, also regulate the width of the excised layer and create smooth and even receiving surface. Until the 20th century Kolokoltsev's dermatome was produced and used as the main tool for performing free skin grafting..

1.1. Free skin autoplasty using autodermotransplant including only skin (non-vascularized):

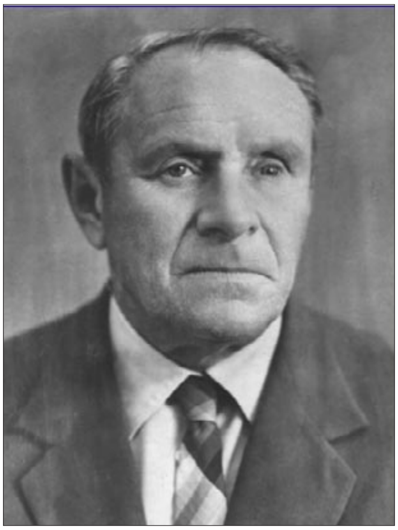
1.1.1. Split: Tiersch method

The method of skin harvesting with split-thickness dermis introduced by Tiersch in 1874 is still successfully applied by surgeons and trauma surgeons for covering of small skin defects and when there is no dermatome in a number of surgical departments.

Figure 1.1. Harvesting of split-thickness autograft by Tiersch with a knife

Figure 1.2. View of the wound and transplant

1.1.1. Split: with dermatome



Michael V. Kolokoltsev (1904-1994) was born in Kazan. He graduated from Medical Institute in Nizhniy Novgorod and was the Chief of the Hospital Surgery Department in Gorkovsky Medical Institute (GMI) (1959-1970). Kolokoltsev is a founder and the first Chief of Trauma Department in GMI (1970-1975). He stared working at Gorkovsky Institute of Reconstructive Surgery, where he performed its number 1 surgery, from the first days of its foundation (in 1946). After the invention of the first Soviet dermatome, Kolokoltsev published his study "Author's dermatome and its use for free skin transplantation" (1947) where he described in details how to work with dermatome and harvest skin autografts. In 1996 he was awarded the academic status of Professor without the defense of a PhD thesis in recognition of his multiple academic achievements – a rear case in clinical medicine.

Figure 1.3. Dermatome invented by Michael V. Kolokoltsev

Figure 1.4. Haversting of split-thickness autodermograft using modern dermatome ДЭ-60 with tangential knife motion

Figure 1.5. Granulating wound is ready for autoplasty; three weeks following the burn

Figure 1.6. Split-thickness autografting without perforation using a transplant with a thickness of 0,25 mm, transplants are placed across

Figure 1.7. Full engraftment in seven days

Figure 1.8. A year after the burn. Plasty on granulations (a predecessor of scar tissue) inevitably leads to scar tissue formation

Figure 1.9. Four days after the injury: deep burn, eschar formation

Figure 1.10. Under tourniquet we perform tangential (using a dermatome) necrectomy up to the lower layers of dermis and exposed subcutaneous fat

Figure 1.11. Plasty under tourniquet using non-perforated grafts with a thickness of 0,2 mm harvested from the right thigh

Figure 1.12. Before discharge; 10 days after surgery

Figure 1.13. Due to early surgical treatment, there are no scars in a year; so we achieved maximum functional and cosmetic results.

Figure 1.14. 4 days after severe burns (flame), up to 60% of deep wounds. Life-saving surgical treatment is indicated.

Figure 1.15. Series of tangential excisions are performed, up to 20% per a surgery once in two days or every day depending on the general state of health

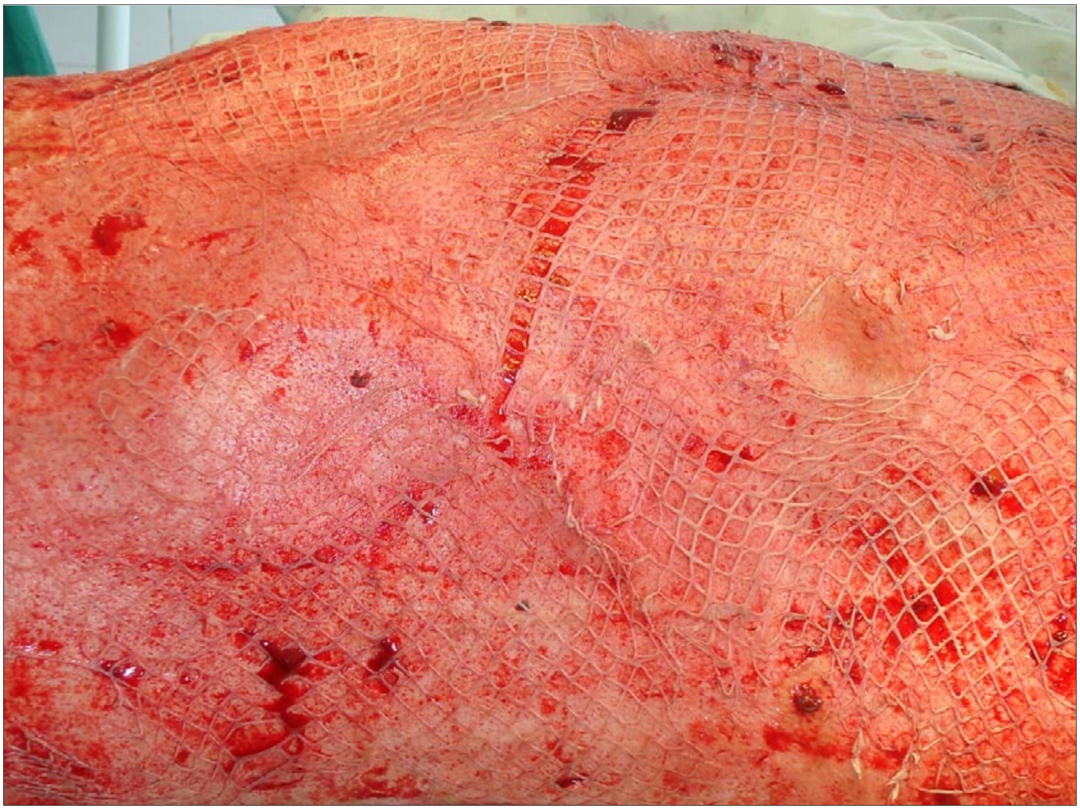


Figure 1.16. Depending on the condition of the wound bed, we perform both primary and delayed atoplasty with perforation

Figure 1.17. Plasty with perforation 1:4 after granulation tissue formation

Figure 1.18. To create optimal conditions for engraftment and mesh epithelization, ChitoPran wound dressing is placed on the plate

Figure 1.19. In case of the lack of donor resources, grafts can be harvested from any area using powered dermatome DE-60

Figure 1.20. Staged engraftment and epithelization within 2 weeks under HitoPran

Figure 1.21. 2 months' results. A powered dermatome is used both for excision of necrotic skin and for harvesting of split-thickness autografts

Figure 1.22. Deep burn (flame) of the back, 3 days after the injury

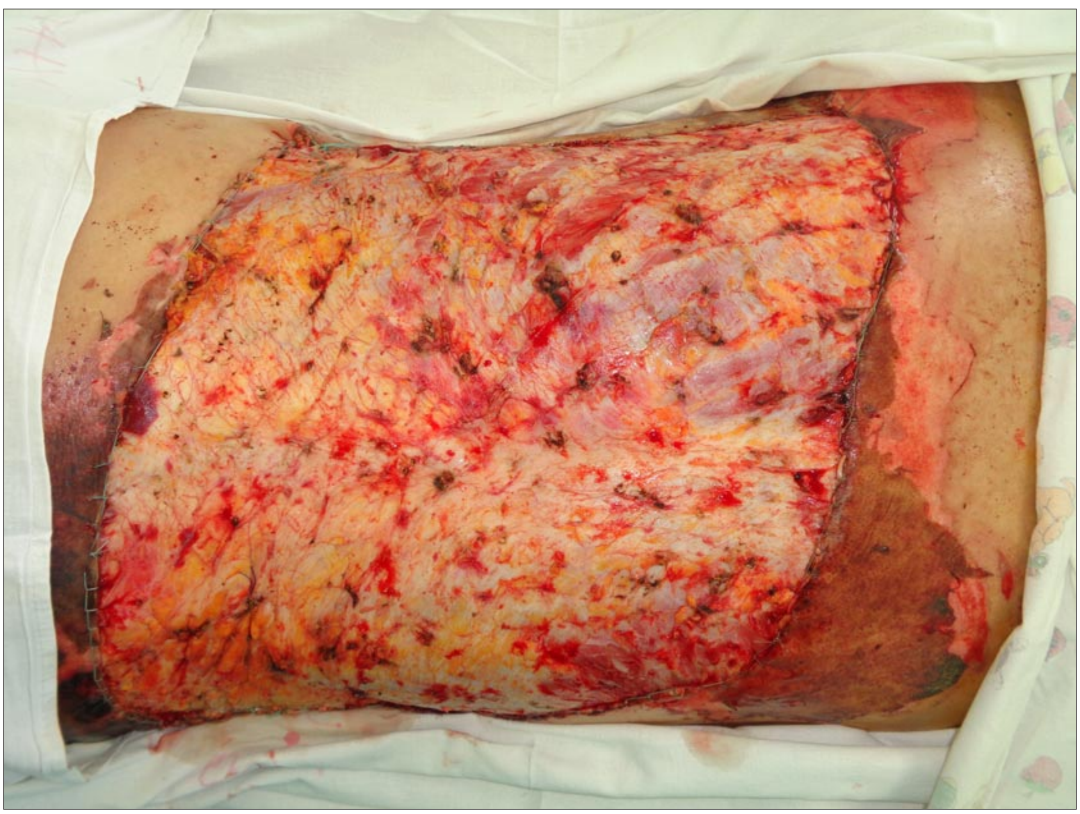


Figure 1.23 . Fascial necrectomy

Figure 1.24. Primary skin plasty using a split-thickness autograft with a thickness of 0,25 mm perforated 1:2

Figure 1.25. We use mesh wound dressing “VoscoPran” with “Braunodin”

Figure 1.26. Vacuum therapy allows improving graft adaptation, and patient can lie on his back after surgery without damage to plasty

Figure 1.27. In 4 days at the first dressing change grafts completely adapt

Figure 1.28. A full-term baby with rare malformation - congenital dermal aplasia of legs and feet, 2 days after birth. No other pathologies.

Figure 1.29. Margin scarring in 7 days, reduced area of aplasia

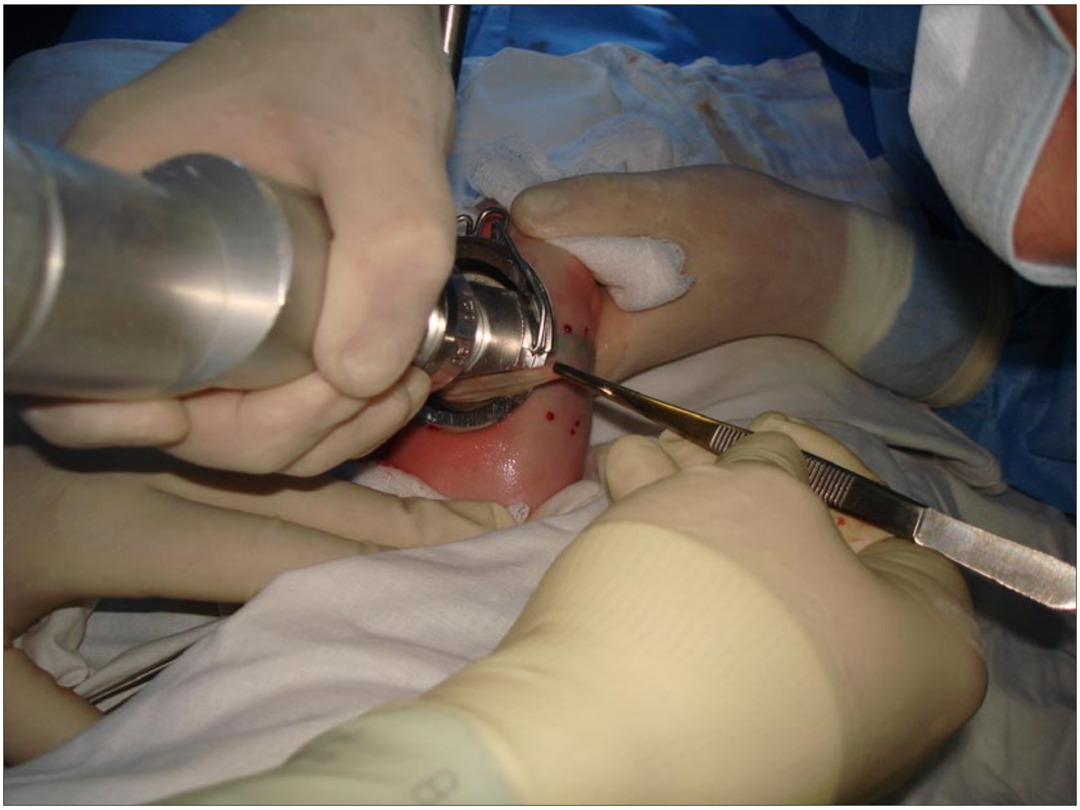


Figure 1.30. 0,2 mm transplant is taken with a powered dermatome DE-40, donor site is previously infiltrated with NaCl 0,9%

Figure 1.31. Fibrin is removed before plastic surgery with a dry napkin

Figure 1.32. Autoplasty, engraftment in 5 days

Figure 1.33. At day 7 (16 days after birth)

Figure 1.34. One year after the burn. The results of 6 month's scarring (staged wound management followed by self-treatment), multiple scars.

Figure 1.35. Scars of the upper extremities and neck are excised at one surgery

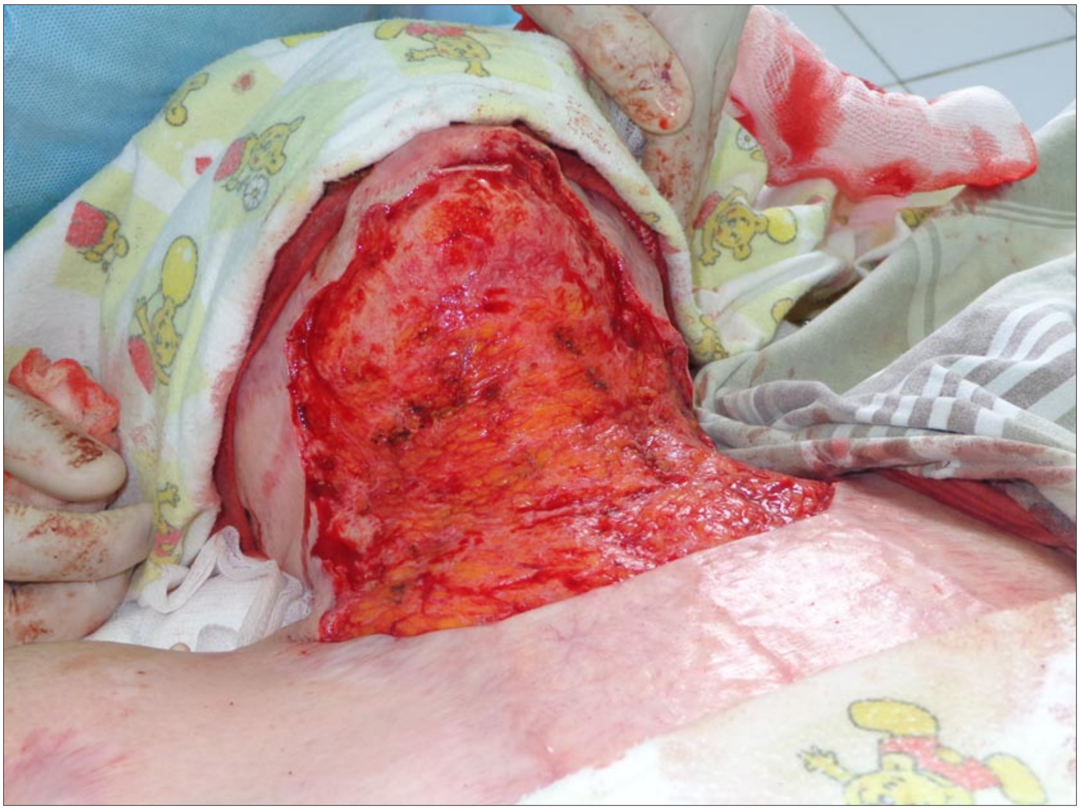


Figure 1.36. Neck contracture is removed by means of excision of the scar tissue

Figure 1.37. Thick grafts (0,7-0,8 mm) are harvested from anterior and lateral surfaces of patient's thighs using a powered dermatome DE-100

Figure 1.38. 1:4 For epithelization and prevention of scarring, the donor site is reconstructed using a perforated 1:4 autograft with a thickness of 0,2 mm

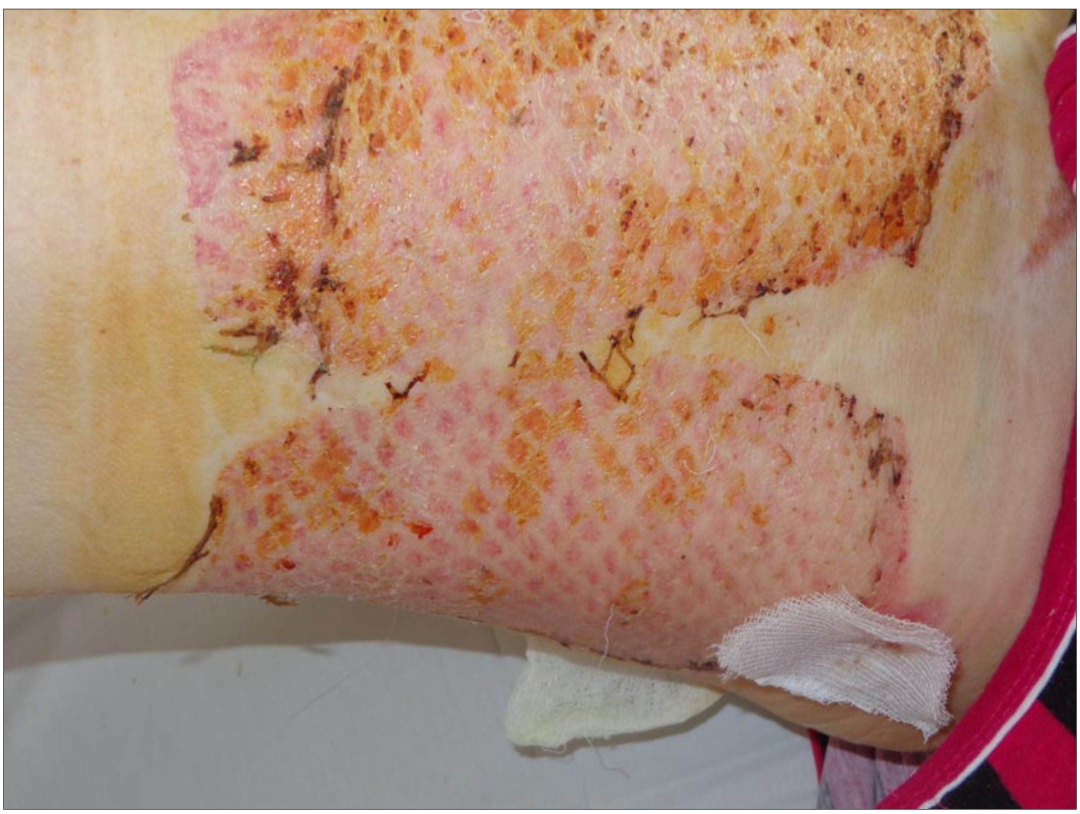


Figure 1.39. Epithelization of the donor site in 12 days

Figure 1.40. Plasty using autodermotransplant with a thickness of 0,7-0,8 mm

Figure 1.41. Thick grafts are sutured by an encircling stitch

Figure 1.42. The full-thickness graft allows preventing scarring with completely reconstruction of motor function

Figure 1.43. Good cosmetic and excellent functional results are achieved in 6 month

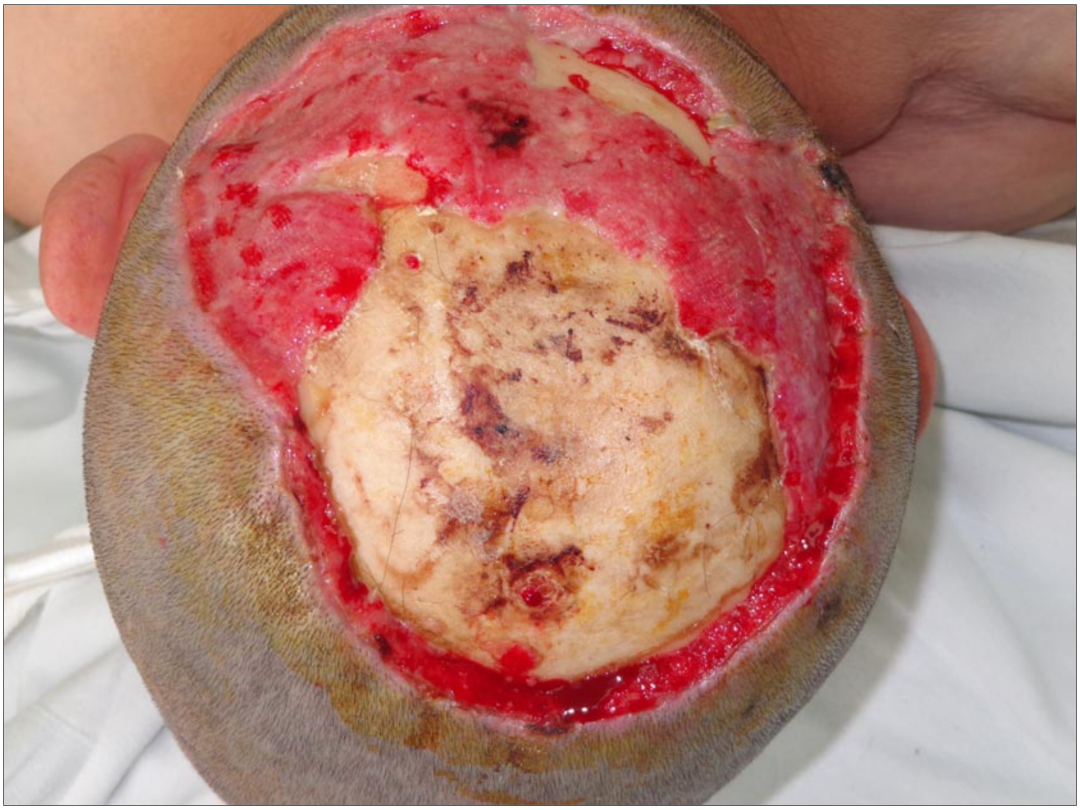


Figure 1.44. One week after the bite wound of hairy part of the head

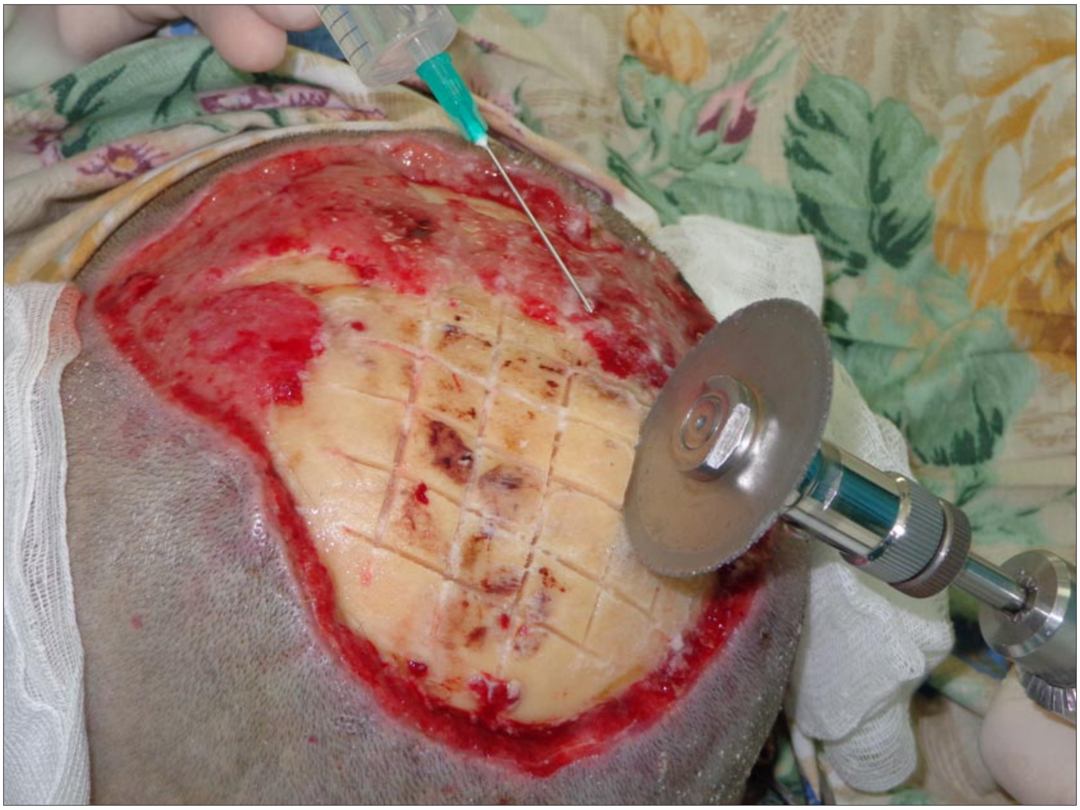


Figure 1.45. Cuts of the upper cortical plate are placed in chequered fashion untill bleeding

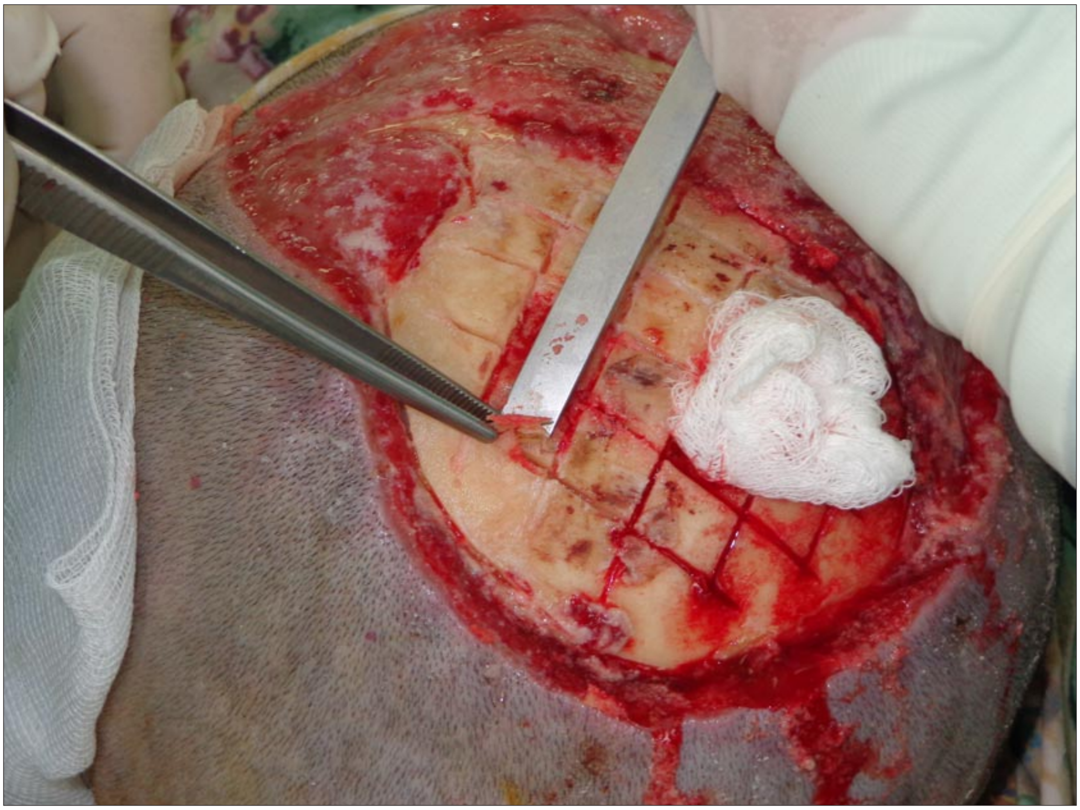


Figure 1.46. Osteonecrectomy till the bleeding layer

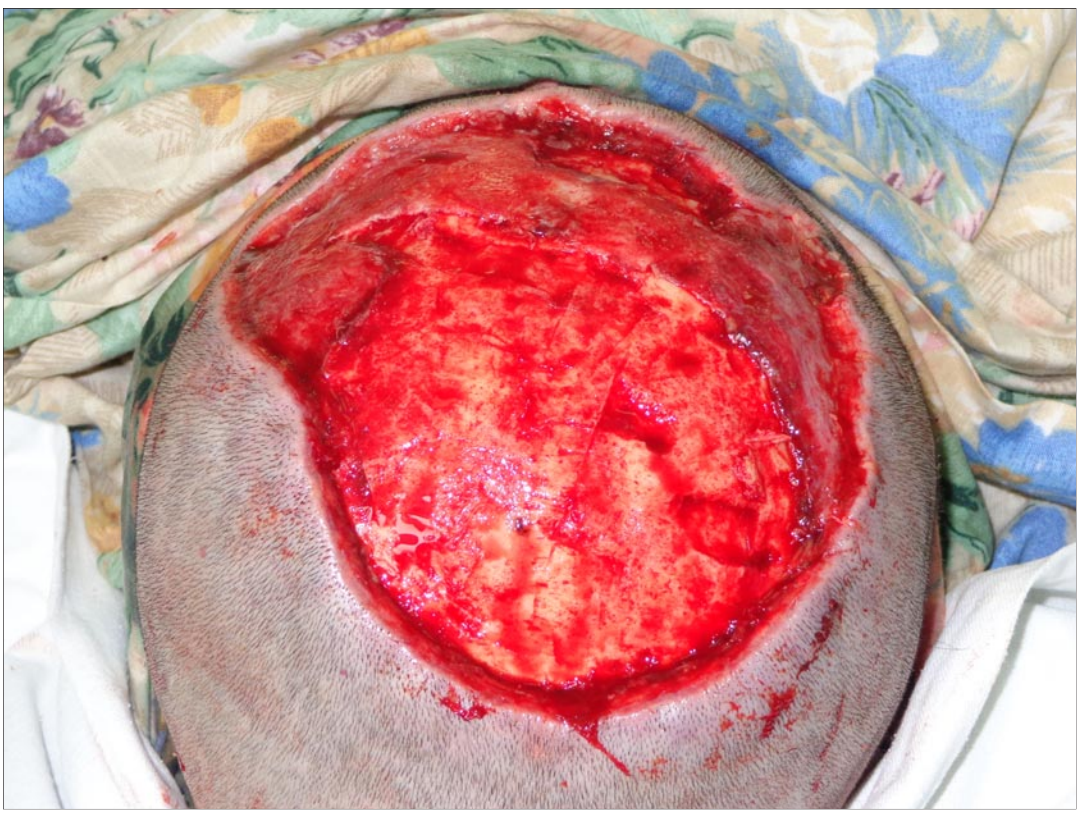


Figure 1.47. Free grafts generally do not survive on the bone, but primary plasty can be performed, provided good blood supply within the bone

Figure 1.48. Plasty using a split-thickness perforated graft with a thickness of 0,25 mm. Minimal stretching of the perforated graft on the bone.

Figure 1.49. Slow transplant engraftment on the bone at day 10

Figure 1.50. Mechanical tear of the male external genitalia

Figure 1.51. Fibrin and upper granulations are excised with a scalpel

Figure 1.52. Autoplastic using a split-thickness autodermotransplant with a thickness of 0,25 mm

Figure 1.53. 3 weeks' results; functions are fully preserved

1.1.2. Full-thickness

Krasovitov method

Vladimir K. Krasovitov (1904-1993) was born in Orlovskaya province. In 1927 he graduated from Kuban Medical Institute. Krasovitov and was the Chief of the Operative Surgery and Topographic Anatomy Department in Red Army Kuban State Medical Institute (1946-1973), Krasovitov also was the Chief Surgeon of Veteran's Hospital, an outstanding scientist and a founder of the thoracic school in the North Caucasus, a man of legend. Krasovitov's plasty using avulsed skin flaps, performed on June 26, 1935, a year before Canadian surgeon made him worldwide recognized. This new technique was introduced on April 4, 1937 at the Smolensk Surgeon Society named after Lister. In 1941 Krasovitov wrote PhD thesis "Primary plastic with avulsed and skin flaps". In 1947 after the war the world known thesis "Primary plastic with avulsed skin flaps", which received the USSR award of Commissariat of Agriculture, was published

Figure 1.54. Detachment of adipo-cutaneous flap following a road accident without skeletal trauma.

Figure 1.55. The flap seems "viable" and many surgeons mistakenly sue the wound that causes flap necrosis

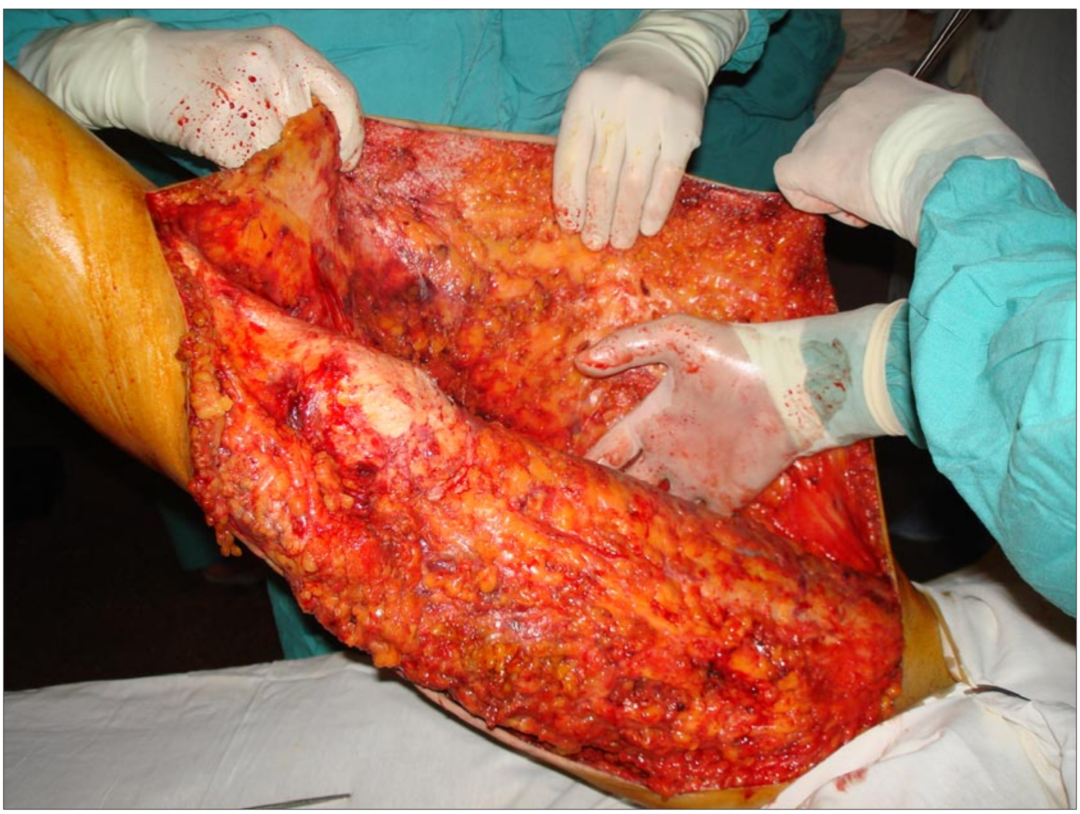


Figure 1.56. Flap is rejected at subcutaneous fat tissue area. No blood supply

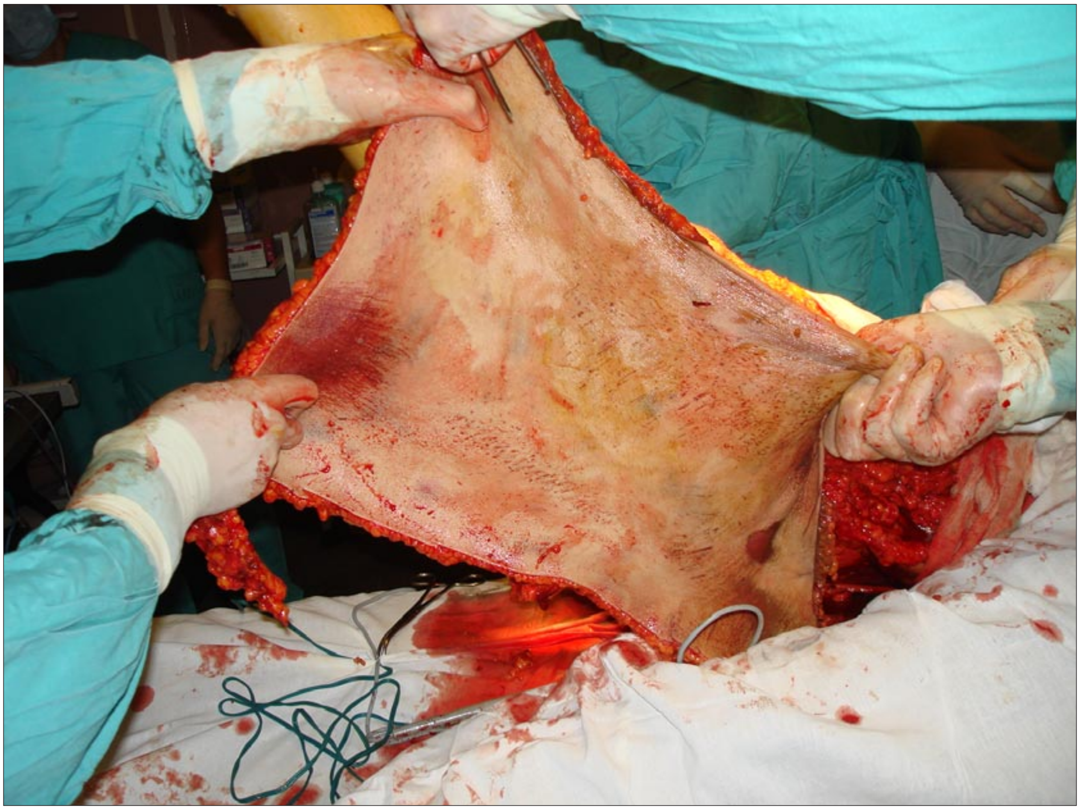


Figure 1.57. The flap should be rejected without pockets

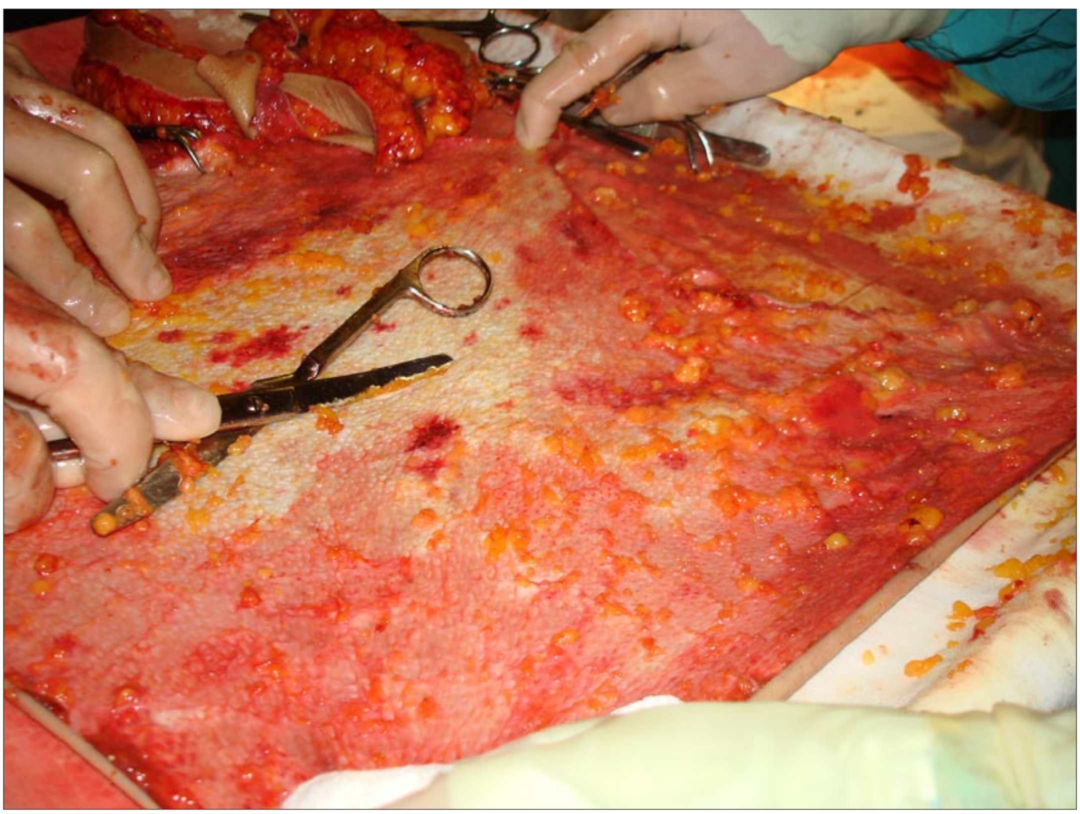


Figure 1.58. Subcutaneous-fat tissue should be completely excised

Figure 1.59. Subcutaneous-fat tissue is also excised from the wound

Figure 1.60. Inner alignment of a full-thickness graft using a dermatome

Figure 1.61. Fat should be completely removed for graft survival

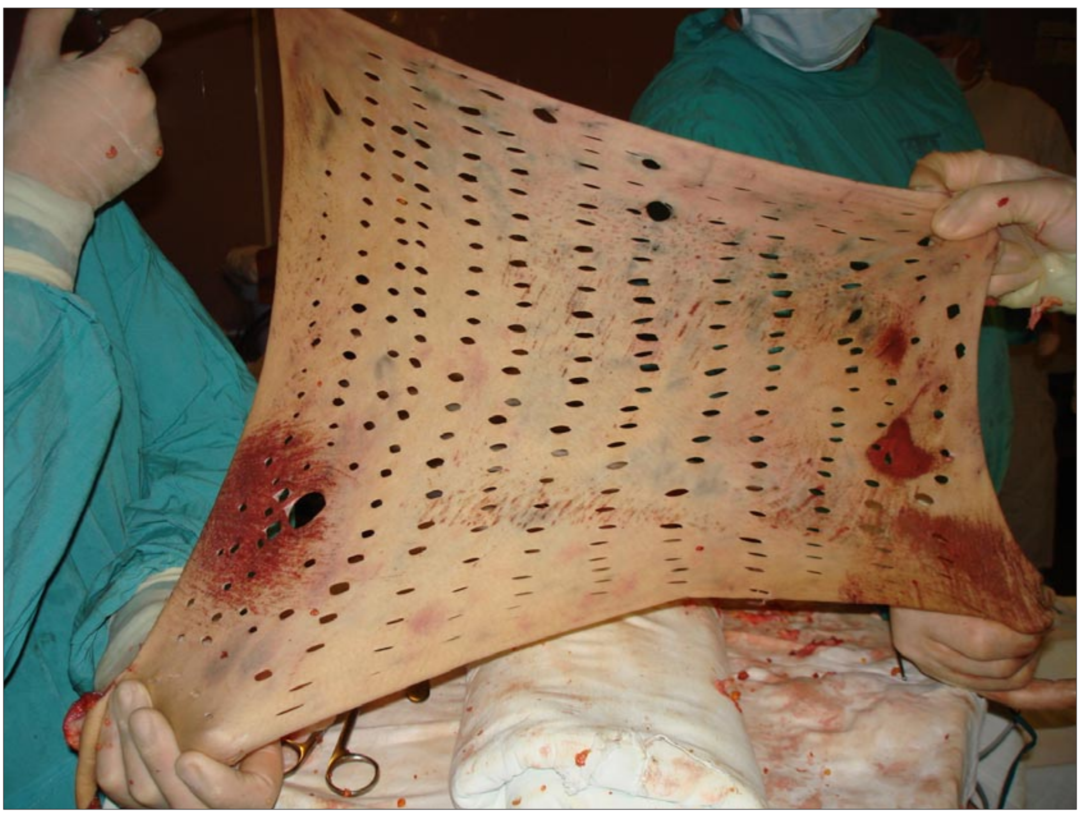


Figure 1.62. Rare perforations are made with a scalpel for wound drainage

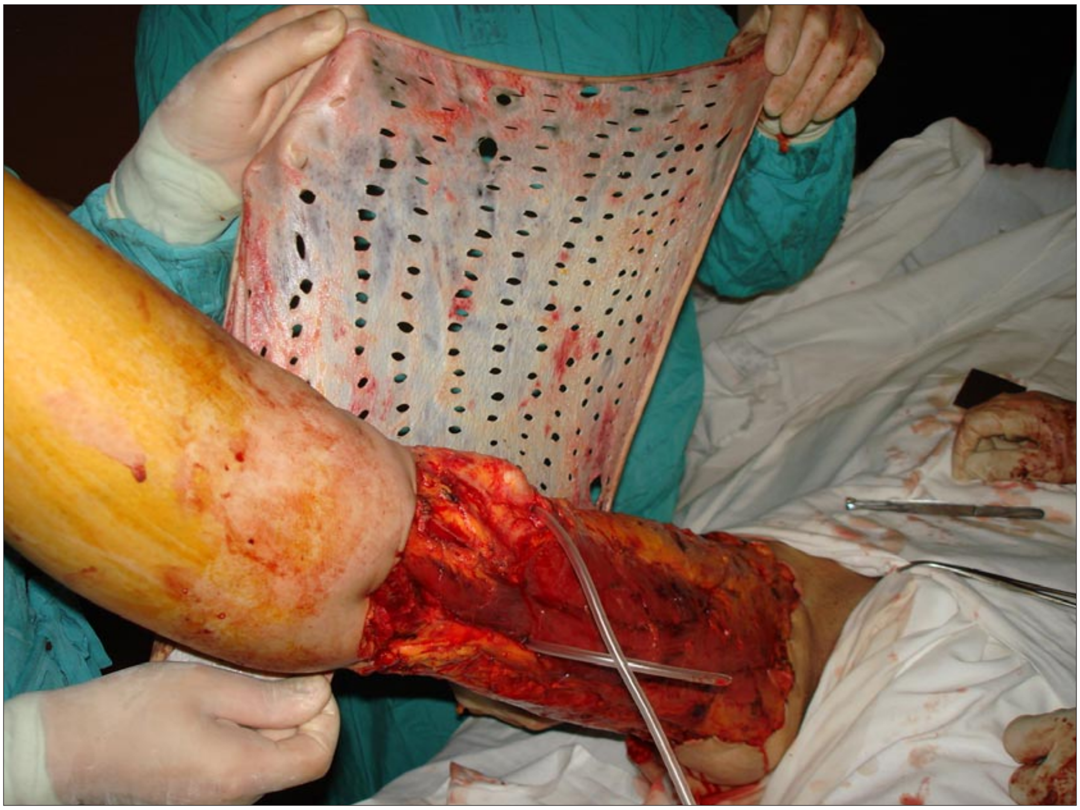


Figure 1.63. Krasovitov's method using a full-thickness skin graft, the first hours after the trauma

Figure 1.64. It is optimal to have two operating teams: one prepares the wound, the other prepares the graft

Figure 1.65. Slow engraftment of full-thickness transplant at day 10

Figure 1.66. Mechanical trauma – torn off hand with a skin flap

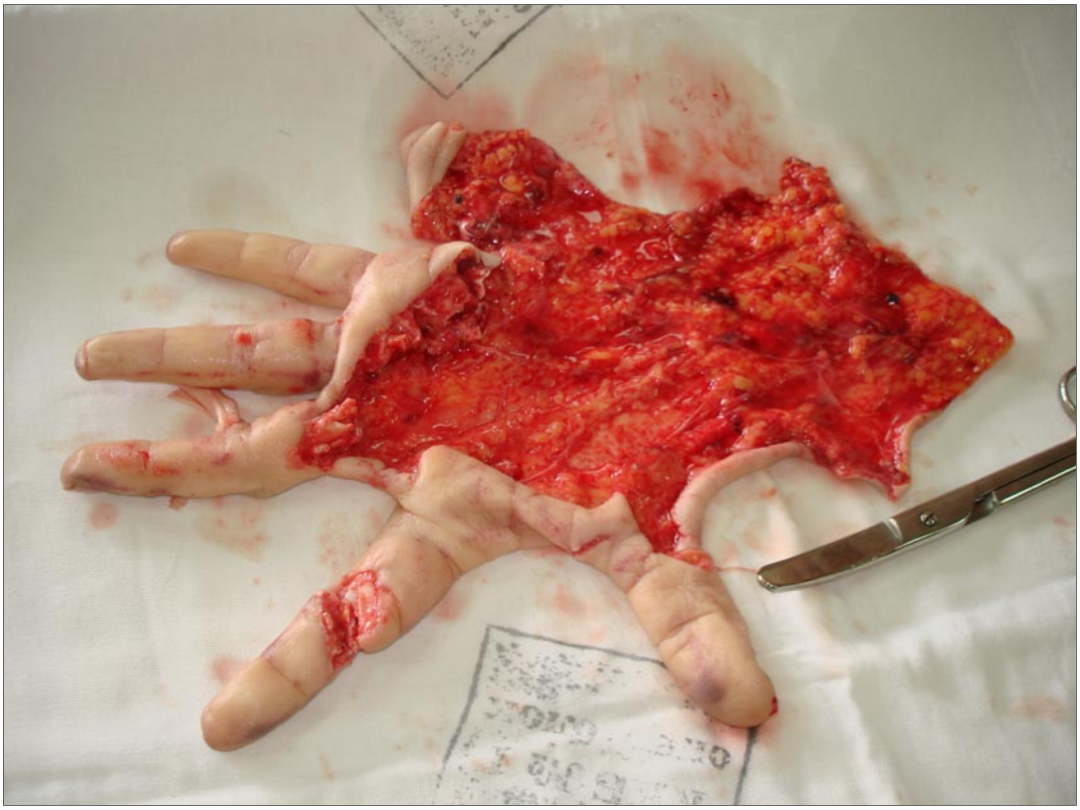


Figure 1.67. Reimplantation of fingers is impossible due to the rupture of vessels. Flap is dissected to prepare the adipo-cutaneous flap and wound

Figure 1.68. Fat tissue is removed from the graft and from the patient's hand

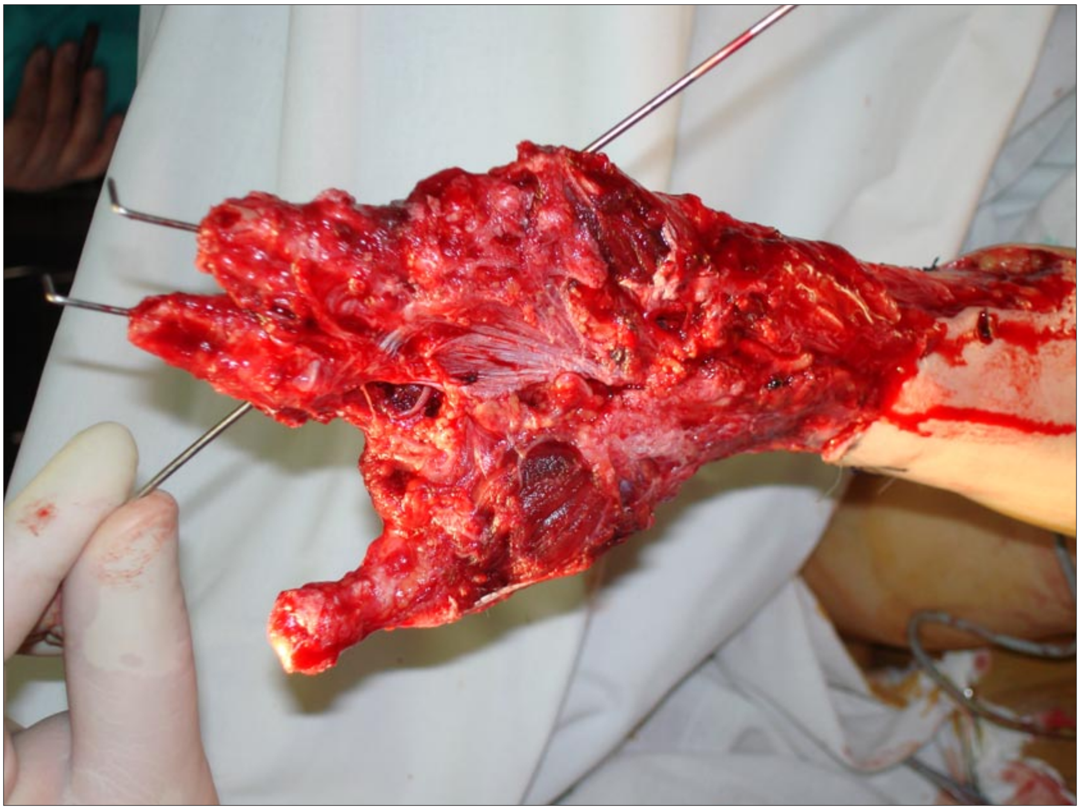


Figure 1.69. 1st interdigital gap is formed

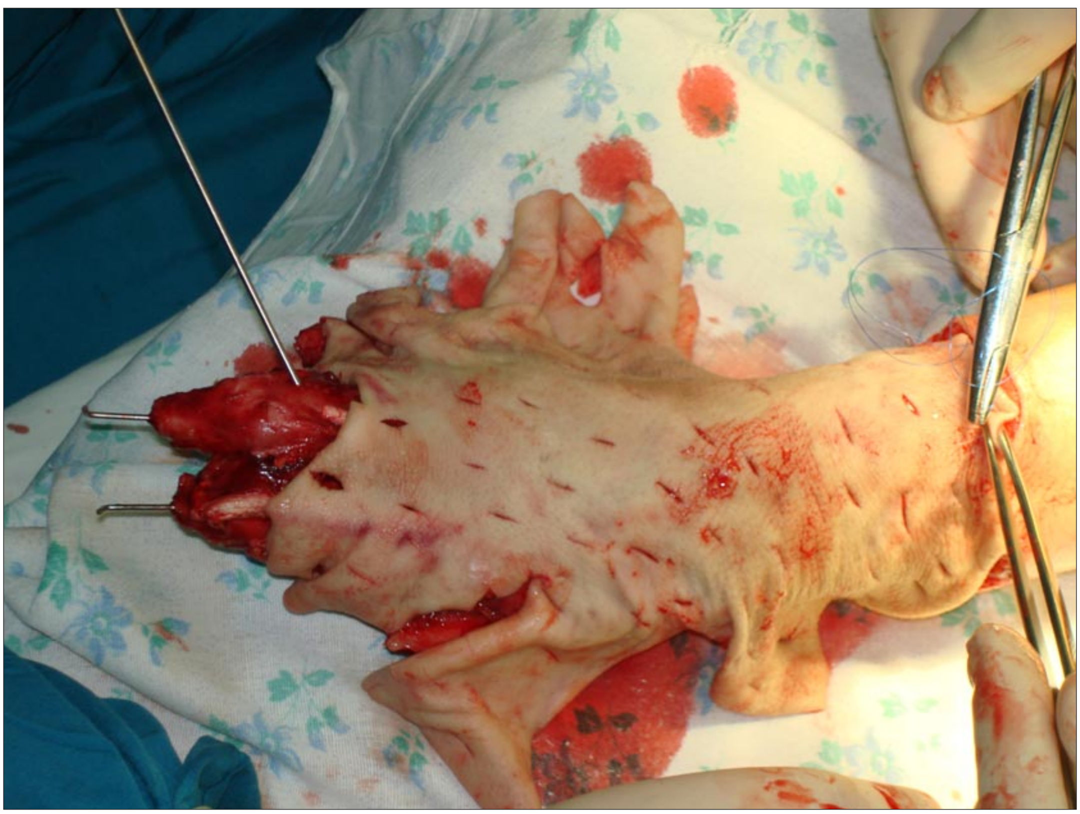


Figure 1.70. Plasty by Krasovitov's method is performed in the first hours after the injury

Figure 1.71. Engraftment of the full-thickness transplant in 7 days

Kuban surgeons are very proud of their compatriot Krasovitov who established a major thoracic school in Kuban. Traumatic detachment of the skin is the result of mechanical injuries when adipo-dermal flap is torn off and exfoliated at the level of the fat tissue. At the first day this skin area gives the erroneous impression that it has normal blood supply. However, the blood supply is damaged. And in 1-2 days skin becomes necrotic with purulent complications unless plastic surgery by Krasovitov is performed. Women with damaged lower extremities generally face a higher risk of such traumas because of the loose subcutaneous tissue. The adipo-dermal flap should be torn off and fat tissue completely removed both from the flap and the wound because fat tissue hinders a full-thickness graft survival. Plasty should be performed within the first day after the trauma. If a patient is in serious condition, a graft can be prepared (fat tissue removed), preserved in saline solution (NSS) followed by plasty in1-3 days until patient's health is stabilized. Krasovitov's method allows closing the wound defect within the first days, reducing the risk of purulent complications and using the damaged skin flap without additional donor skin.

Parin metho

Boris V. Parin (1904-1968) was born in Kazan. His father Vasiliy founded Perm surgical school, one of the largest peripheral schools in Russia. In 1927 he graduated from medical Department in Perm University. In 1928 he conducted the first blood transfusion in Ural. Since 1932 till 1935 Parin established blood service in Udmurtiya. Since 1935 Parin was the Chief of the Department of Operative Surgery, since 1938 till 1944 – the Chief of the General Surgery Department. In 1935 the degree of Master of Medical Science was conferred on him without thesis defense and PhD in 1939 (also prior to his thesis defense). The both facts are unique and demonstrate the recognition of his great success in science. In 1994 Parin with his father granted money to the Red Army for production of a tank T34. In 1950 Parin was repressed and sent to Gorkiy where he worked in Gorkiy Medical University, and since 1957 and until last he was the Academic Director of Orthopaedic Trauma Institute

Figure 1.72. Post-burn scar contracture of the foot after self-treatment

Figure 1.73. Excision of scars, removal of deformities, no tendon excision

Figure 1.74. Harvesting of a full-thickness graft according to Parin's method

Figure 1.75. Subcutaneous tissue is removed with scissors , “smoothed dermis”

Figure 1.76. Primary sutures are placed on the donor site

Figure 1.77. Full-thickness autografting of the clear wound

1.2. Composite autodermotransplant on microvascular anastomosis (vascularized):

1.2.1. Fascio-cutaneous;

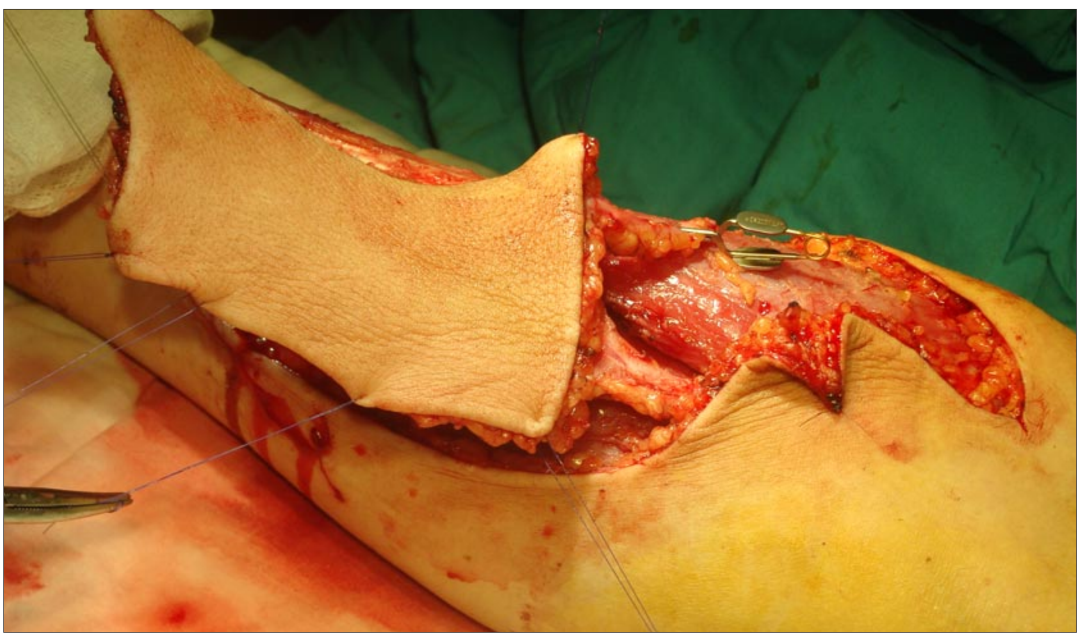


Figure 1.78. Harvesting of a pedicle radial flap

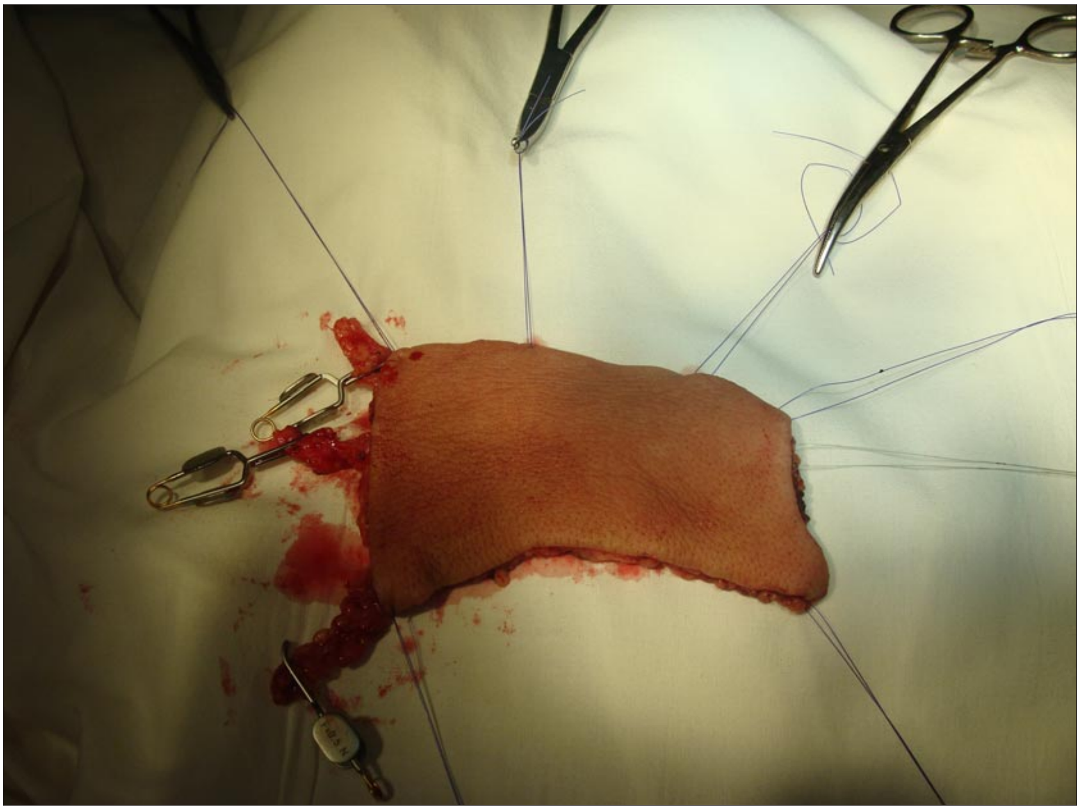


Figure 1.79. Harvesting of the radial flap with vein and artery exposure

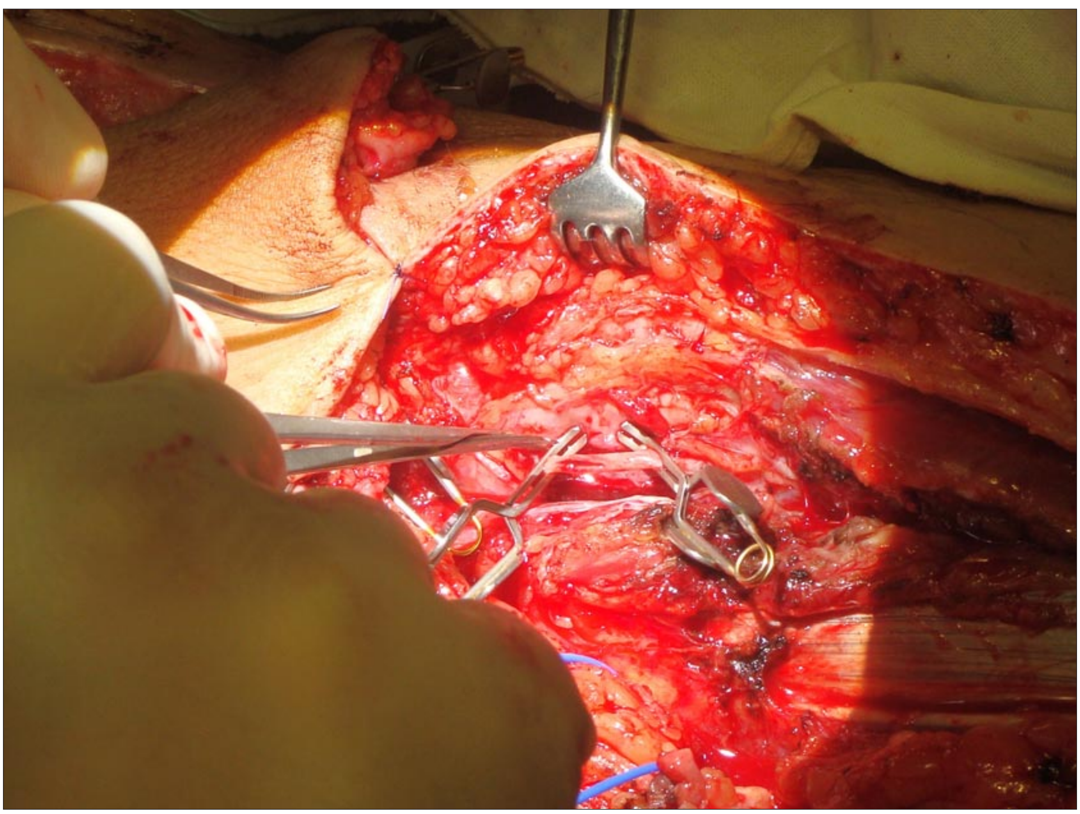


Figure 1.80. Vascular “end-to-side”anastomosis

Figure 1.81. The wound defect is closed with the pedicle radial flap

1.2.2. Musculo-cutaneous, also with a bone fragment

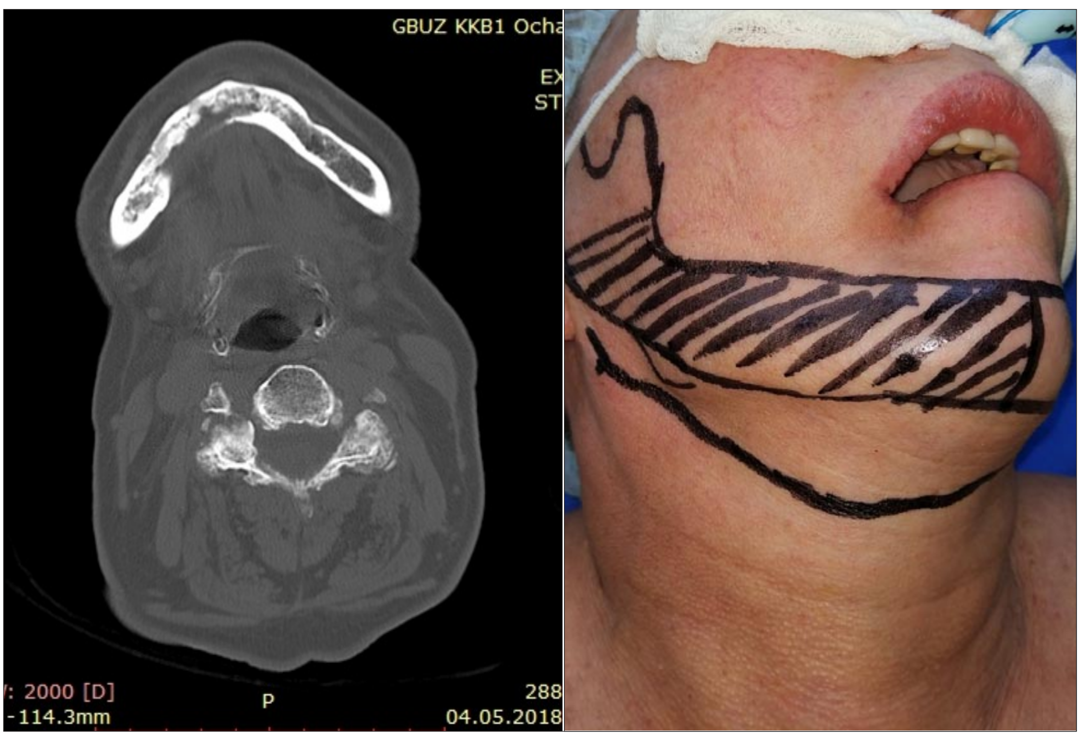


Figure 1.82. Tumor of the lower jaw and mouth, approach and resection

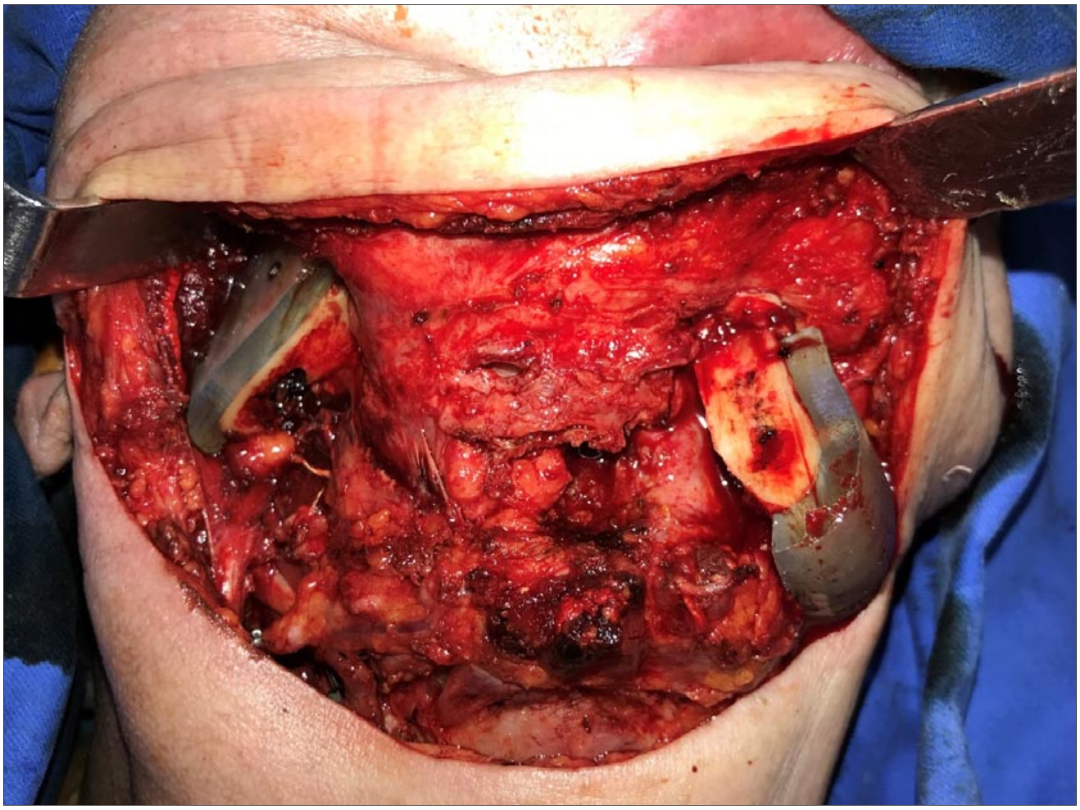


Figure 1.83. Resection of the tumor and lower jaw using submandibular approach

Figure 1.84. Measuring of a musculo-cutaneous flap with the splint bone

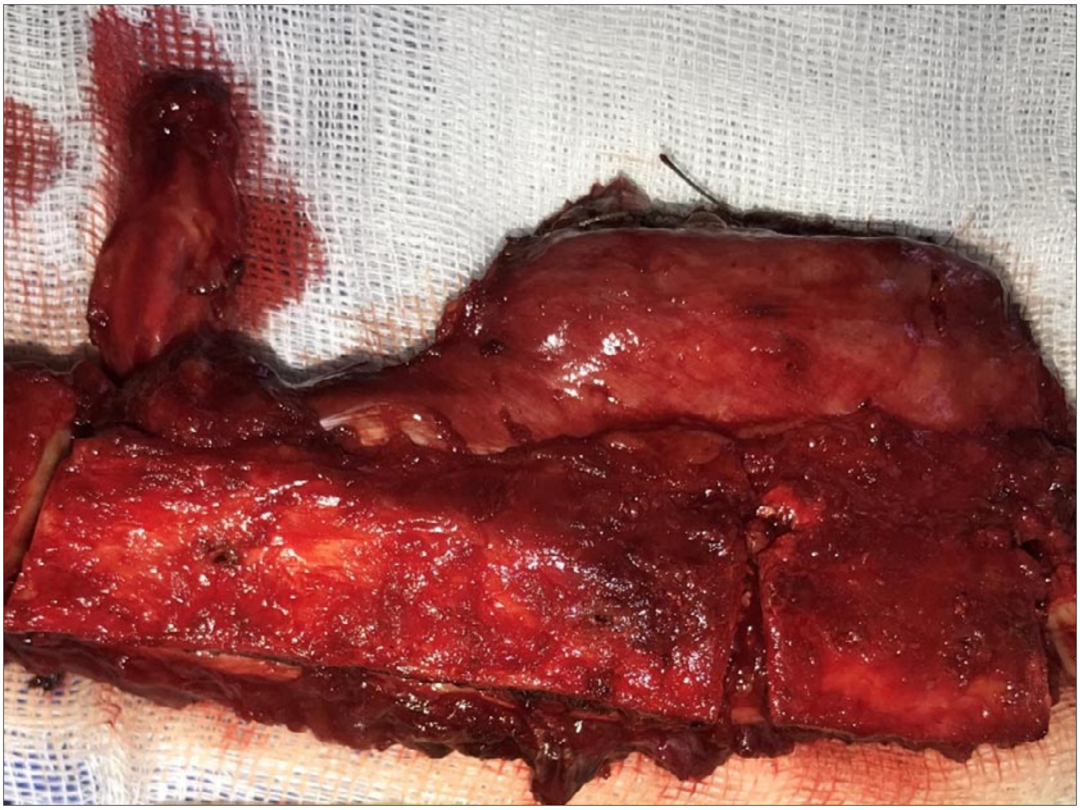


Figure 1.85. Harvesting of the musculo-cutaneous pedicle flap. The lower jaw is designed from the splint bone using 3D reconstruction.

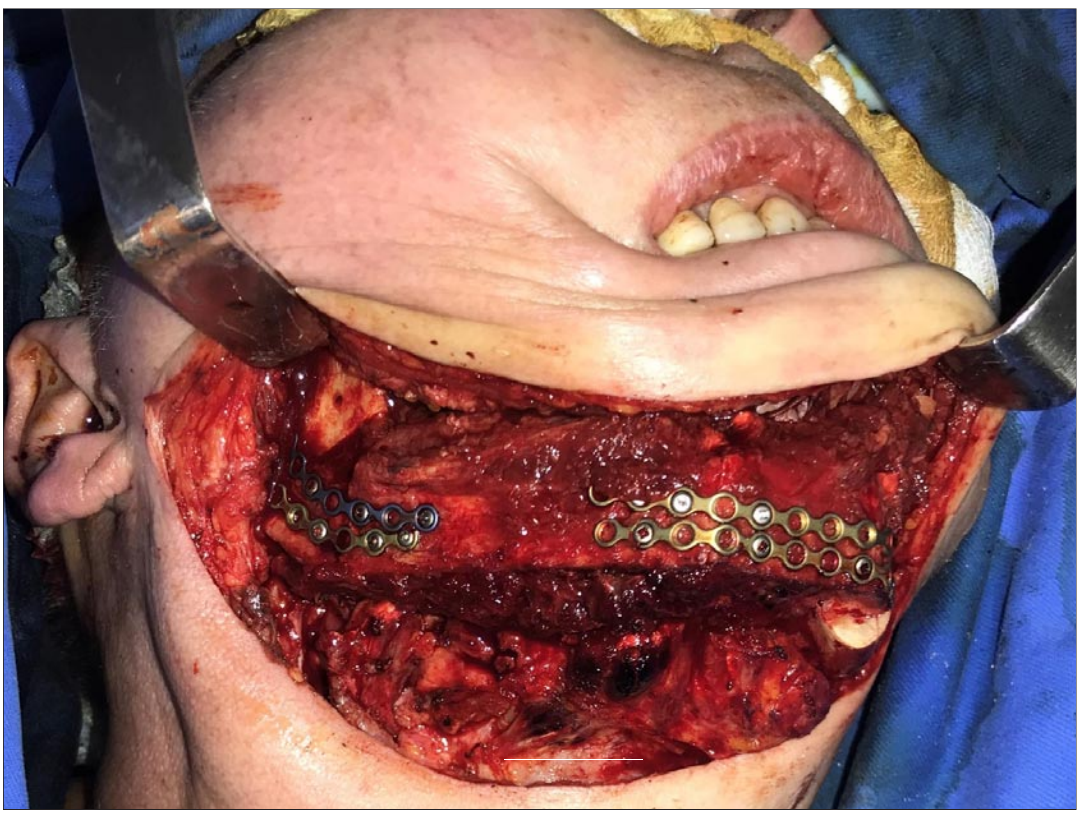


Figure 1.86. Microvascural plasty, metallosteosinthesis

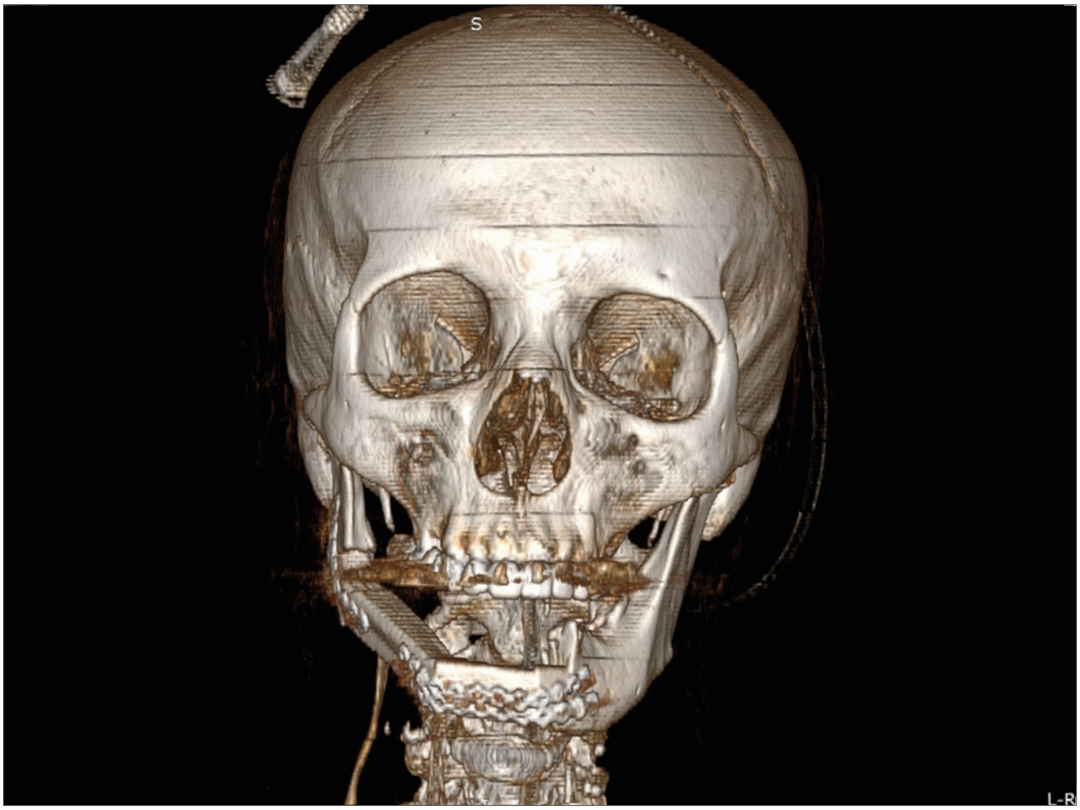


Figure 1.87. 3D reconstruction after the surgery, preserved function

Figure 1.88. The flap is viable. The flap is harvested from the leg to the mouth cavity

Figure 1.89. 7 days after the surgery

Since 70th years of the 20th century, following the development of microsurgery for the closure of wound defects plasty on vascular pedicles, both rotative and free, with microvascular anastomosis was rapidly introduced. There is no doubt that fast closure of large wound defects performing only one surgery has more advantages than several stages of classical plasty using adipo-cutaneous flaps. To perform such operations a surgeon should understand the specific of microvascular surgery. Generally, patients with maxillofacial traumas, and also patients with hand injuries and their complications are candidates to flap plasty with vascular pedicles. Fascio-cutaneous and musculo-cutaneous pedicle flaps with a bone component require end-to-end or end-to-side microvascular anastomosis of arteries and veins. These surgeries must have invariable indications.

CHAPTER 2.
NON-FREE SKIN PLASTY

2.1. Using local tissues-acute dermotension

Figure 2.1. Contact burn of the left clunis

Figure 2.2. Suturing following necrosis excision and mobilization of local tissues

Expander dermotension

Figure 2.3. 10,000 Volt deep electric burn

Figure 2.4. Staged necrectomies, osteonecrectomy

Figure 2.5. Formation of the granulation tissue, including the dura

Figure 2.6. Free split-thickness autografting

Figure 2.7. In 6 months we are planning to implant endoexpander to remove scars and reconstruct the adipo-cutaneous tissue with following cranioplasty

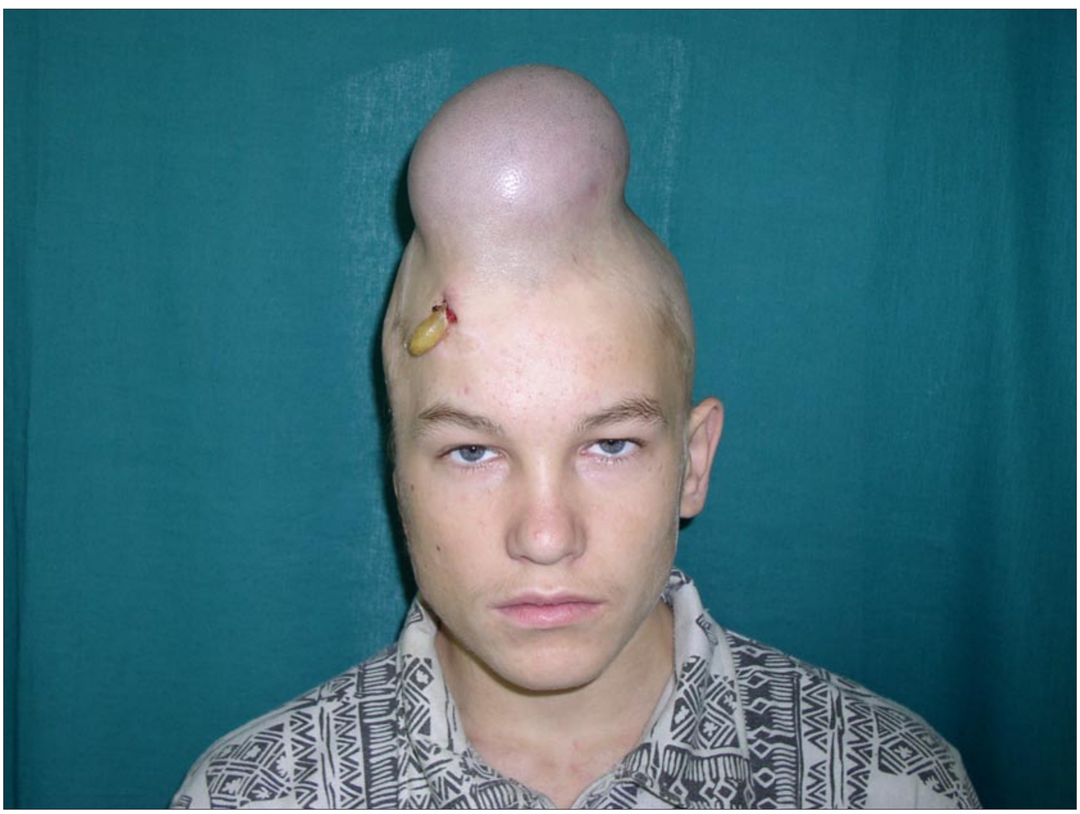


Figure 2.8. Implanted endoexpander, its head leaves outside. expander dermotension is performed within 2 months

Figure 2.9. One year after plasty with the adipo-cutaneous flap and cranioplasty we observe positive functional and cosmetic results.

Figure 2.10. Expander dermotension is performed to prevent scar deformities of the mammary glands

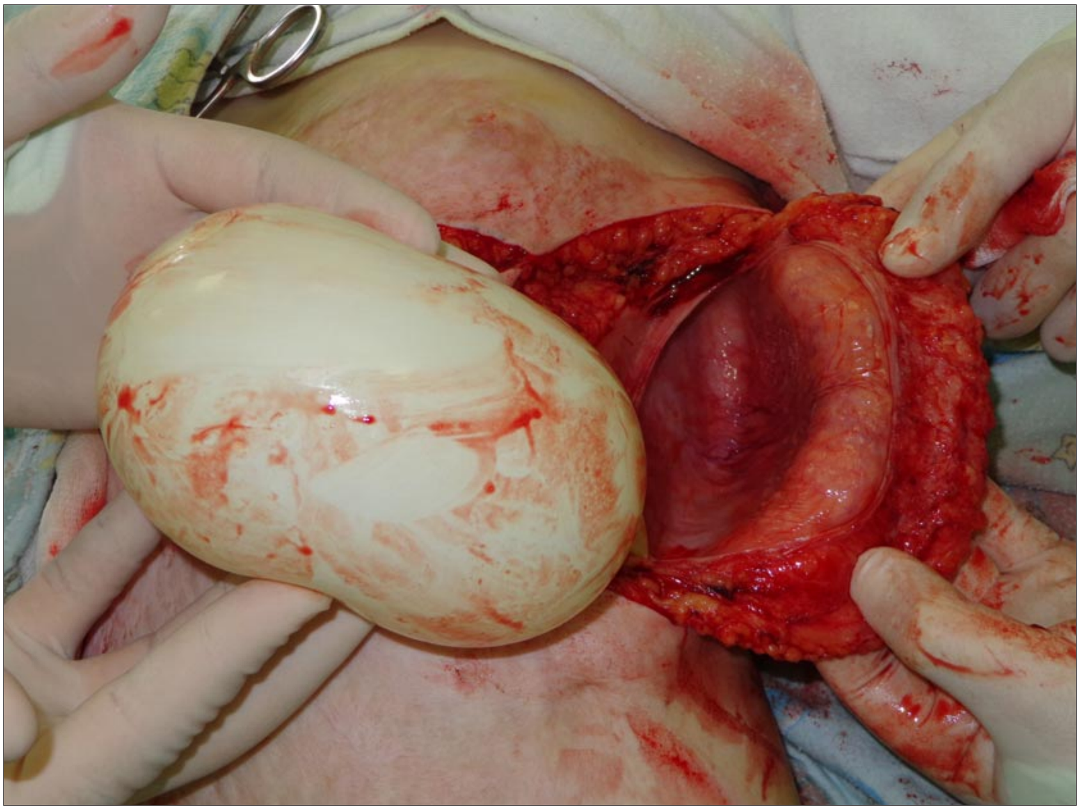


Figure 2.11. Removal of the expander, the expander capsule on the flap

Figure 2.12.. Excision of body scars, preparation of adipo-cutaneous flaps saving the expander capsule

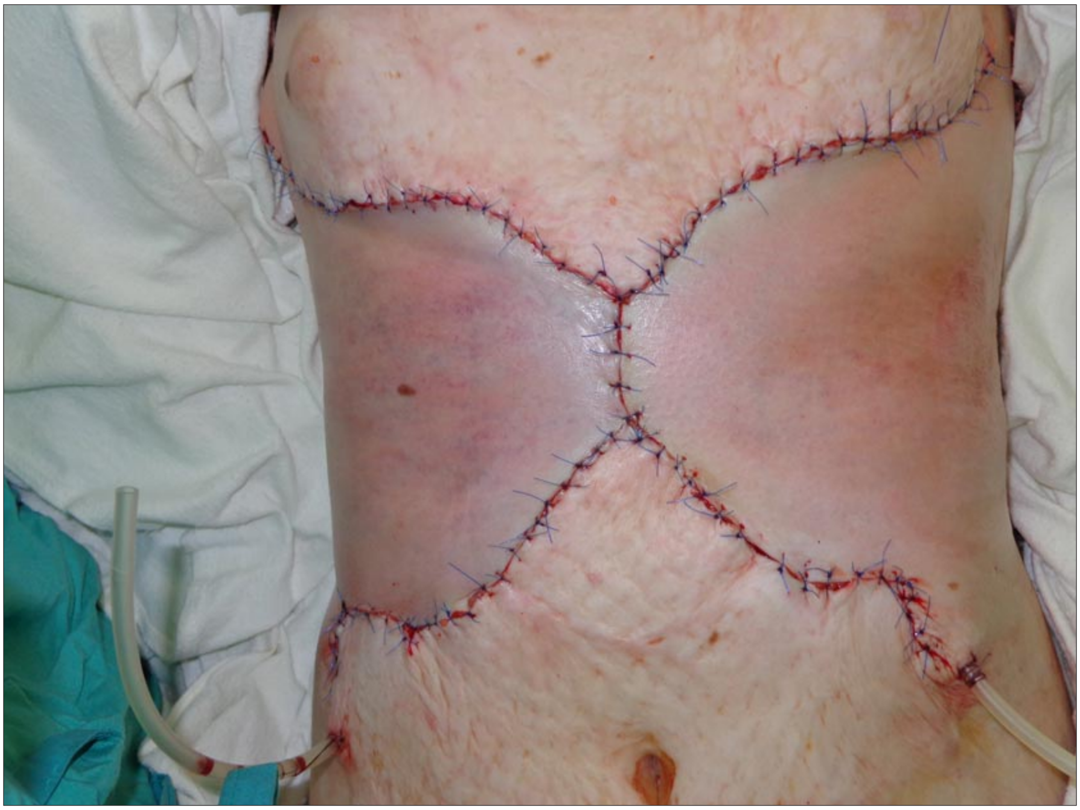


Figure 2.13. Initial deformation of the mammary glands is removed

Figure 2.14. Normal tissue growth of the mammary glands in two years

Figure 2.15. Post-injury scar, defect of the local tissues and the 5th metacarpal

Figure 2.16. Expander dermotension is performed

Figure 2.17. Plasty using an adipo-cutaneous flap with scar excision

Figure 2.18. Bone plasty (using adipo-cutaneous flap) in a year

2.2. Distant flap grafting (island, flat or tube) on regular or temporal pedicle: *Indian plasty*

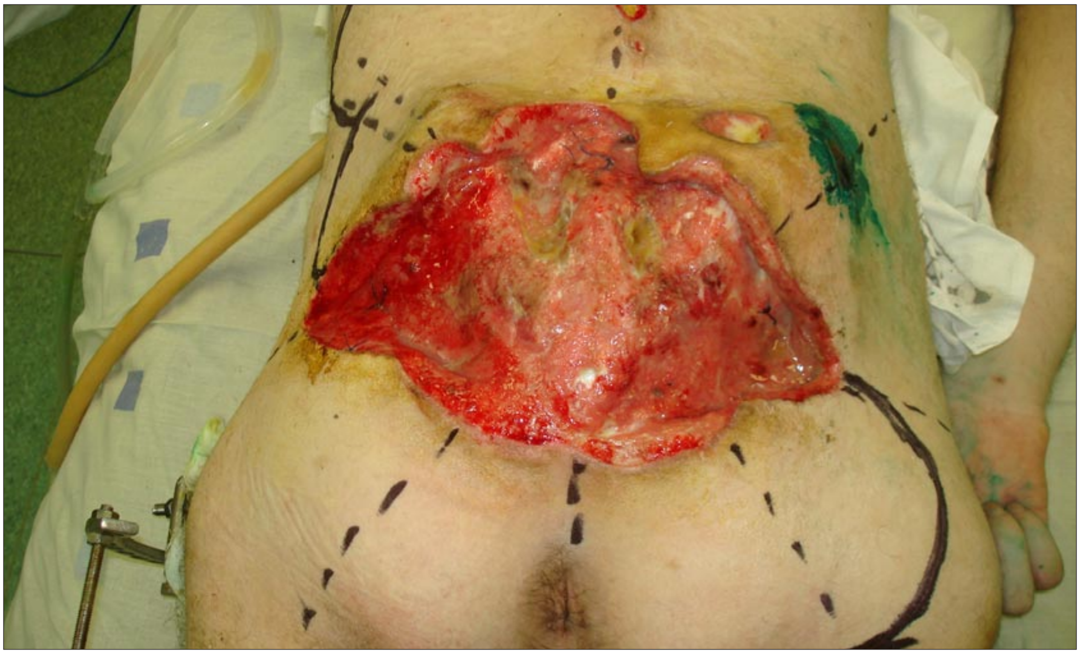


Figure 2.19. Bedsores with exposed bony structures

Figure 2.20. Adipo-cutaneous "petaled" flaps

Figure 2.21.. Transposition of “petals”, Indian plasty

Figure 2.22. Post-radiation nasal ulcer, plasty with an adipo-cutaneous flap is indicated

Figure 2.23. Plasty with a rotation adipo-cutaneous flap harvested from the forehead

Figure 2.24. The donor site is sutured or, depending on indications, - free plasty.

Figure 2.25. Plasty results in a month

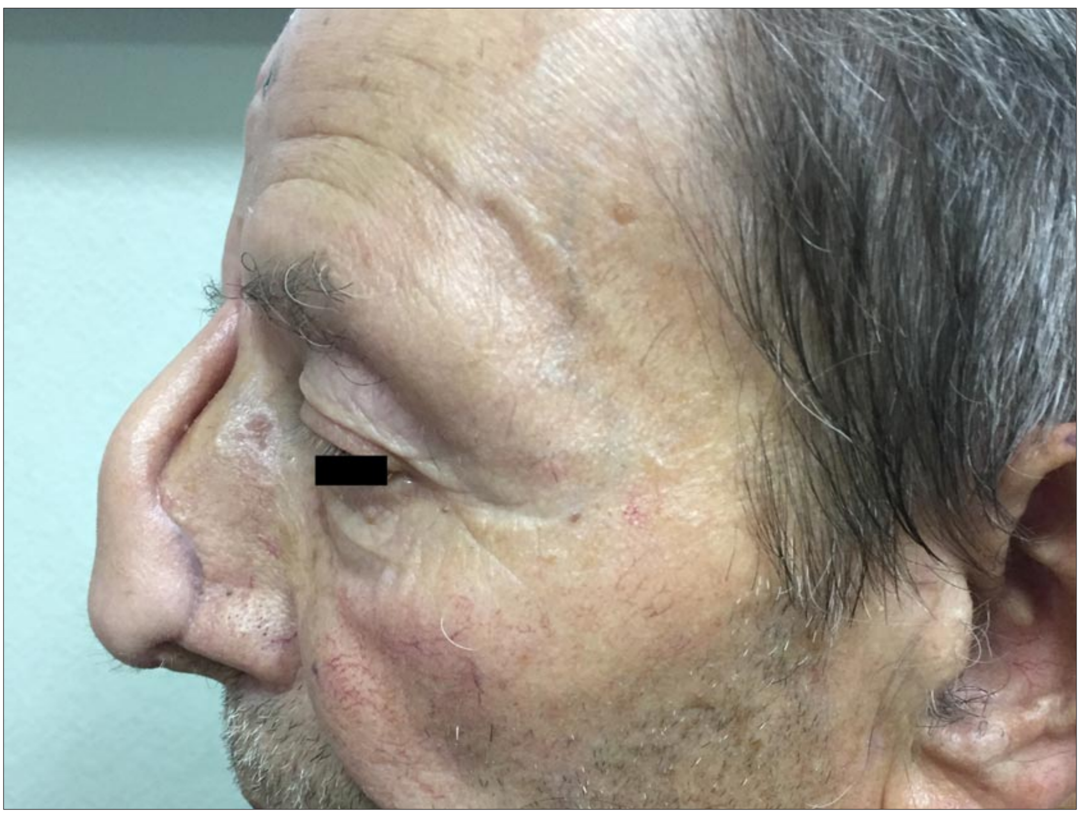


Figure 2.26. Plasty of nose tip, in a month the pedicle was dissected

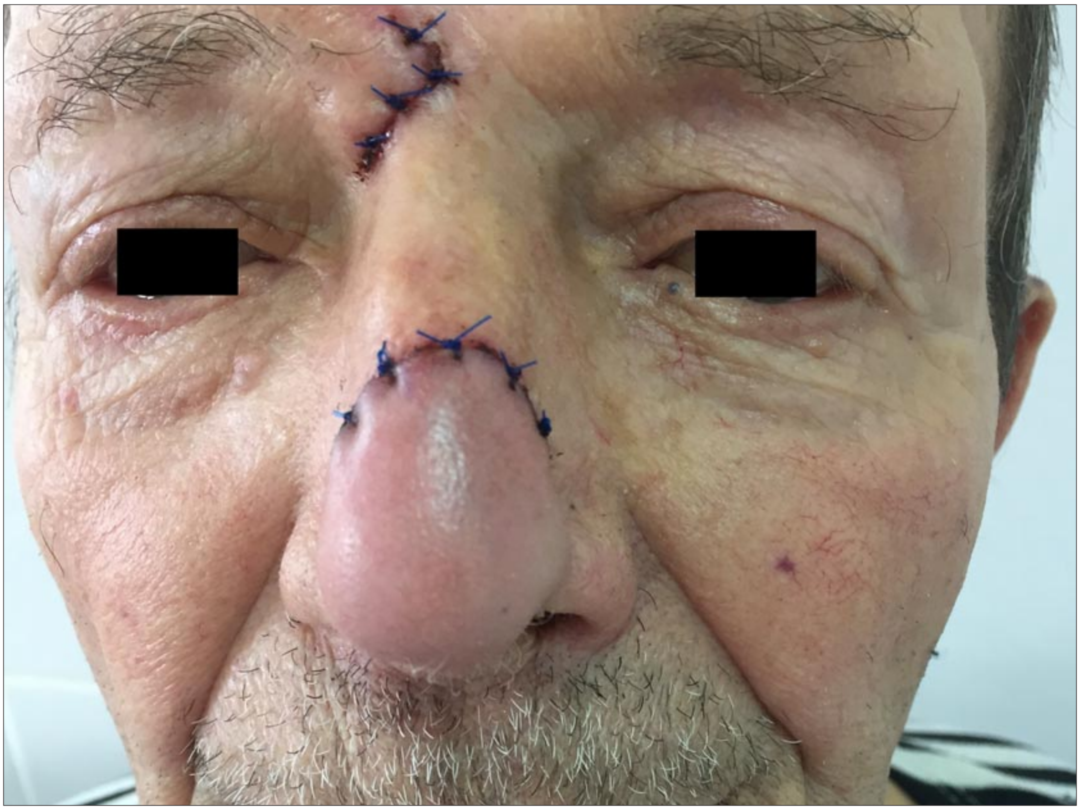


Figure 2.27. After dissecting of the pedicle at the nose bridge

Italian plasty

Figure 2.28. High- voltage electric burn, 3 days after the injury

Figure 2.29. Necrectomy for saving of the deep anatomical structures, plasty with an adipo-cutaneous flap is indicated

Figure 2.30. Italian plasty with one pedicle to the bone, a double pedicle flap is placed to the V finger, a rotation flap - to the forearm

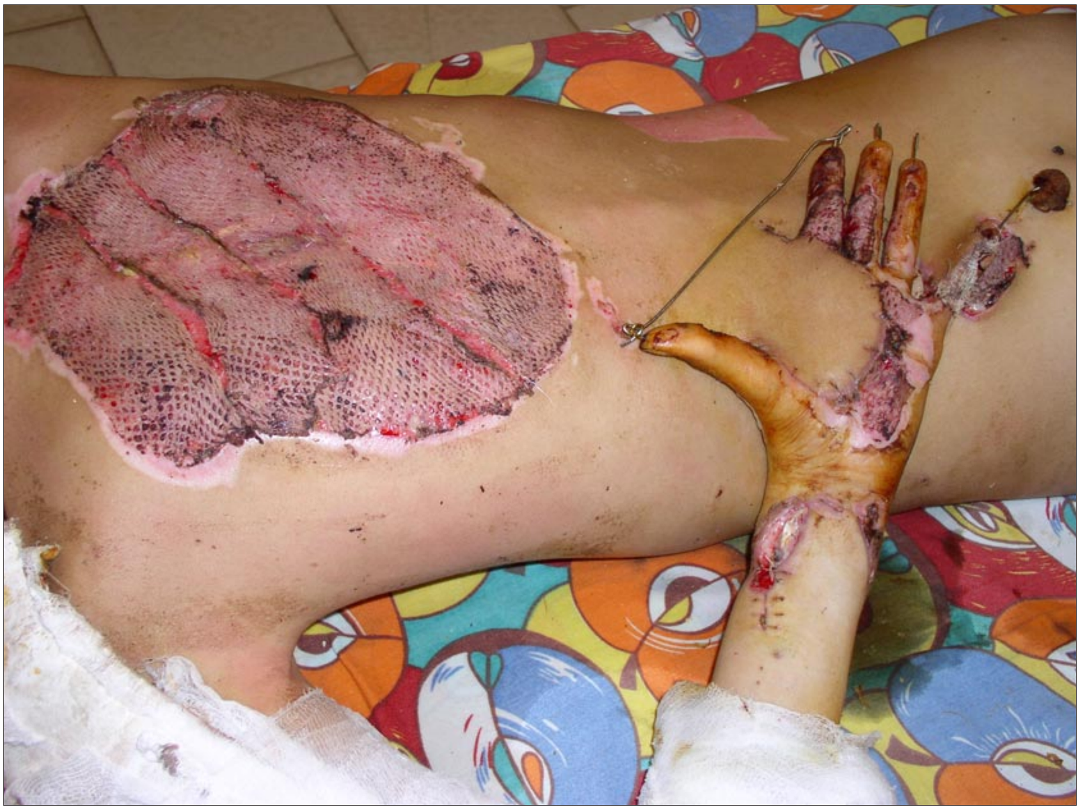


Figure 2.31. Split-thickness autografting is performed on the back at “current output”. The hand is “sutured” to the back, 3 weeks

Figure 2.32. In 3 weeks flaps are cut off, the hand and tendon are preserved

Figure 2.33. After mechanical injury with a circular exposure of the tendons, the finger “sewn” into subcutaneous fat tissue of the abdomen

Figure 2.34. Sharp trainings of the flap in 2,5 weeks

Figure 2.35. In 3 weeks the finger and the flap are dissected from the “abdomen”

Figure 2.36. The flap is viable 1 week after surgery

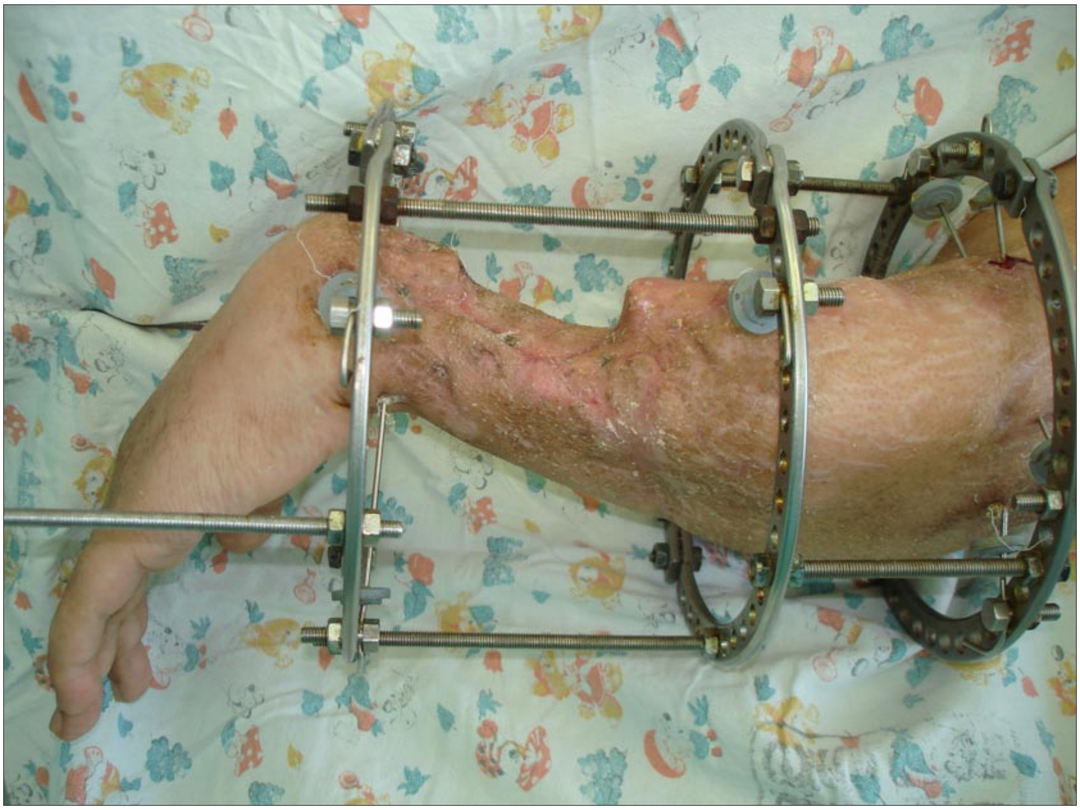


Figure 2.37. Defect of the local tissues and forearm. We "need" an adipo-cutaneous flap before bone plasty

Figure 2.38. Scar excision, formation of an adipo-cutaneous flap on the abdomen

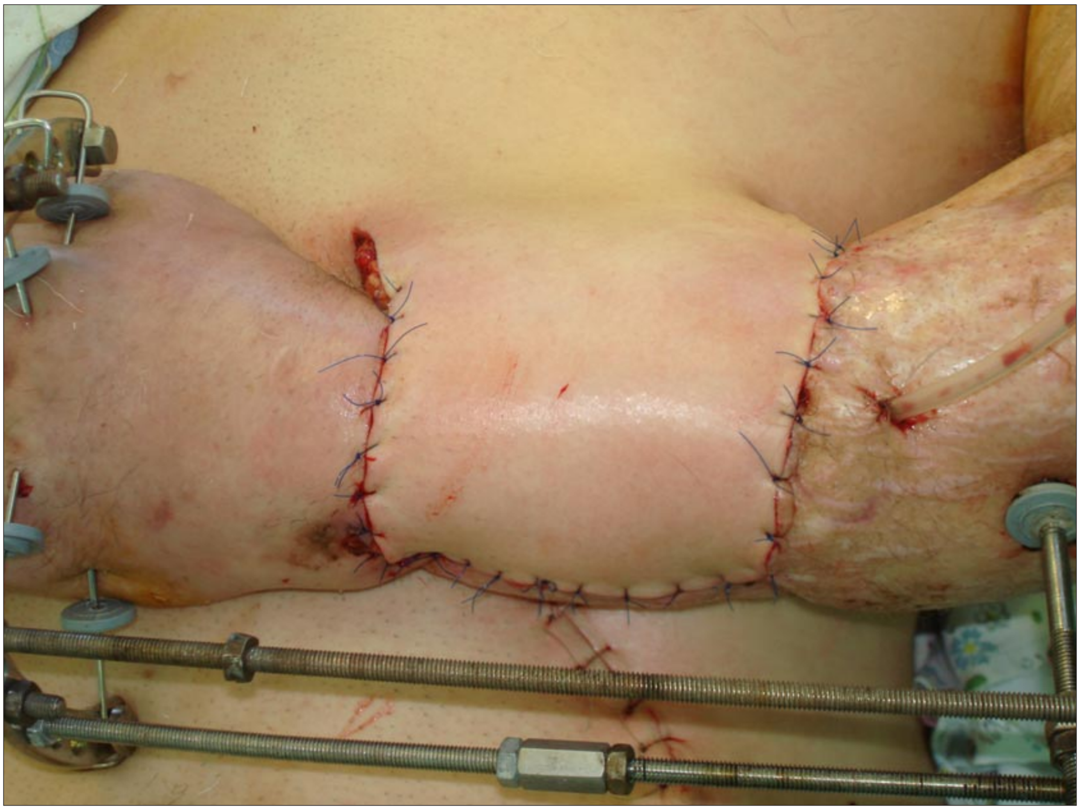


Figure 2.39. Classical Italian plasty

Figure 2.40. In 3 weeks and within 2 days a pedicle is dissected, skin suturing

Figure 2.41. One year old child with the electric burn (children's combustiologist deal with such cases very often)

Figure 2.42. Excision of necrosis, exposure of tendons and a joints of the 3d finger. Plasty with an adipo-cutaneous flap is indicated

Figure 2.43. Plasty with a split-thickness graft with a thickness of 0,25 mm

Figure 2.44. Tendons on the palmar surface are also exposed

Figure 2.45. Two adipo-cutaneous flaps are formed

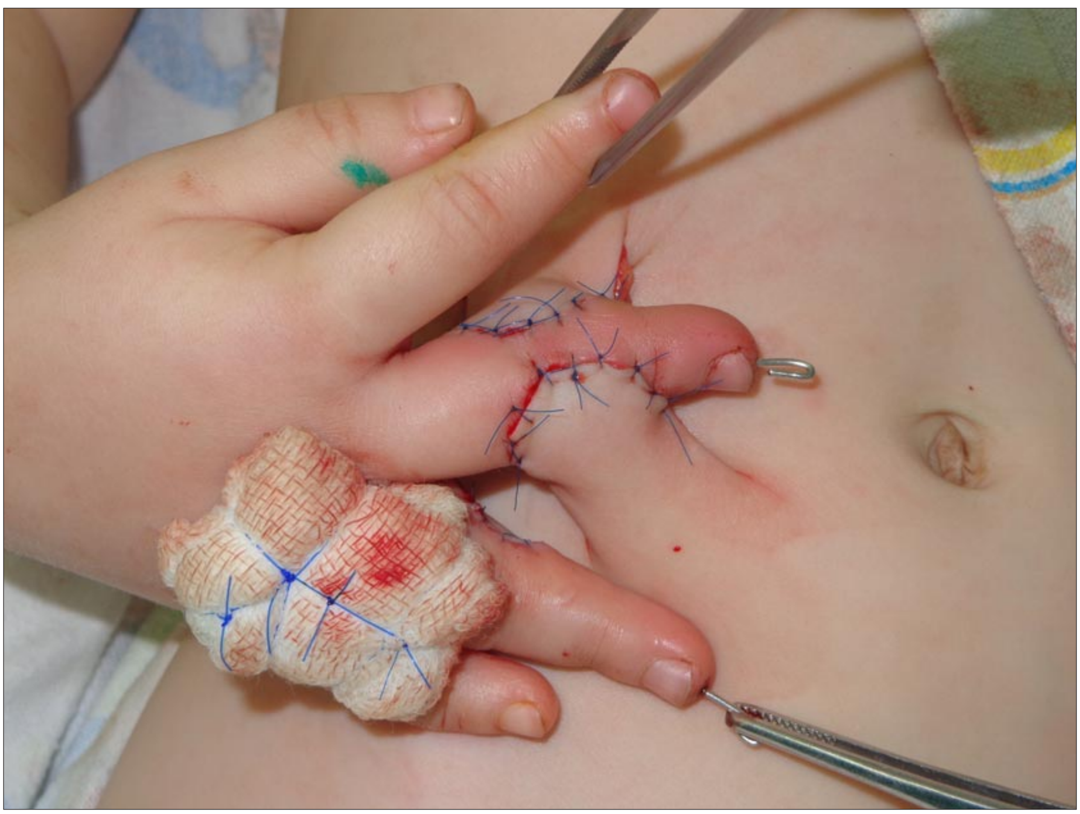


Figure 2.46. Italian plasty with two flaps

Figure 2.47. In 2,5 weeks the pedicles are cut off, tendons preserved

Figure 2.48. Results of plasty with temporal pedicle flaps. Plasty with 1-5 flaps on the fingers of both hands may be performed in other patients, if indicated

Filatov method

Vladimir P.Filatov (1875-1956) was born in Penzenskaya Province. Immediately after graduation from the Moscow Medical University in 1897 he started working as an ophthalmologist. Since 1903 he worked in Odessa where he became the Chief of the Novorossiysk Eye Clinic in the Department of Medicine (Odessa). He contributed to trachoma research, diagnosis and treatment of glaucoma, studied the problem of cornea transplantation. Filatov created the doctrine of biogenic stimulators. In 1916 Filatov offered the original method of plastic surgery with the tube pedicle flap (Filatov flap). In this technique the adipo-cutaneous flap is tubed and then gradually migrates to different area of the body for closure of soft tissue defects o f various genesis.

Figure 2.49. Marking of the double adipo-cutaneous flap – for a stem

Figure 2.50. Mobilized adipo-cutaneous flap is sewn into the tube

Figure 2.51. Free autoplasty is indicated when it is impossible to repair the donor bed

Figure 2.52. Migration of the skin in every two months of trainings

Figure 2.53. Stages of migration and vascular training of the area that will be dissected

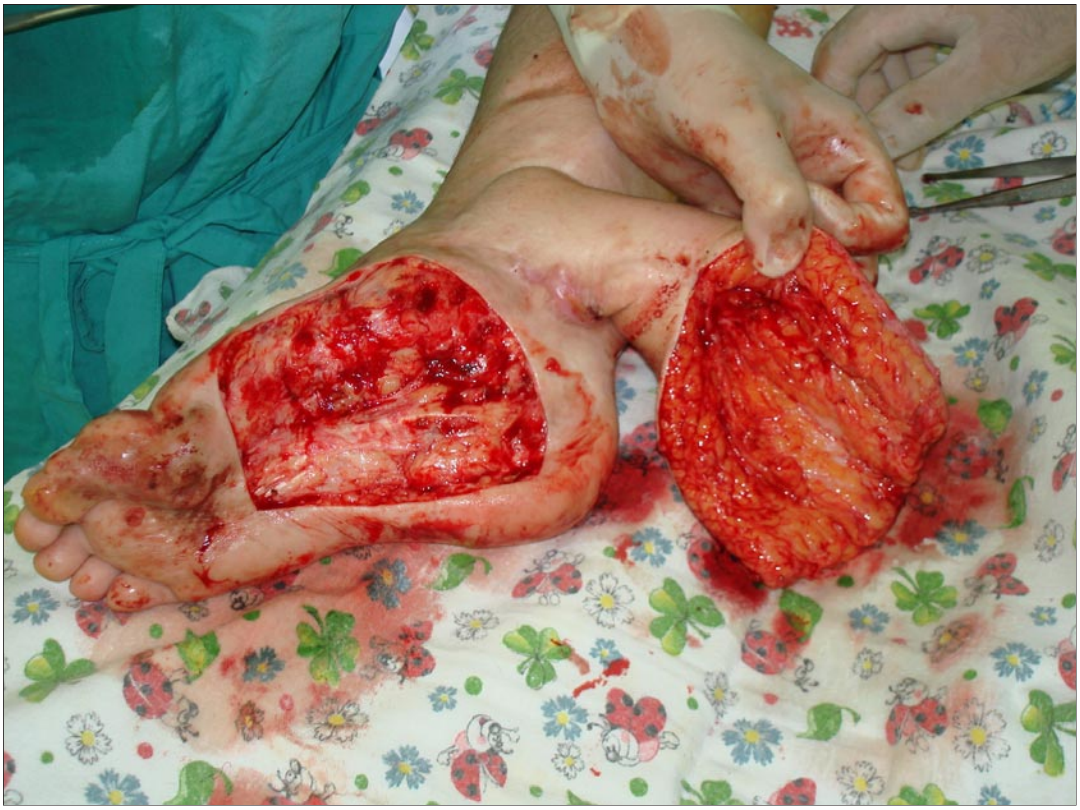


Figure 2.54. Full blood supply in the Filatov's stem

Figure 2.55. Last stage of plasty with Filatov's stem

Figure 2.56. Results of 5 migrations of the Filatov's stem (10 months treatment)

Figure 2.57. Post-traumatic defect of the nose after a car accident

Figure 2.58. Free skin plasty on the granulating wounds

Figure 2.59. Filatov's tubed stem is formed on the left shoulder

Figure 2.60. In a month after training of the stem leg preparing of accepting bed on the forehead, at the nasal root

Figure 2.61. Migration of the distal stem from patient's shoulder to forehead

Figure 2.62. Forced position of the patient at the treatment stage (during 1,5 month)

Figure 2.63. Pedicle is dissected, stem is viable

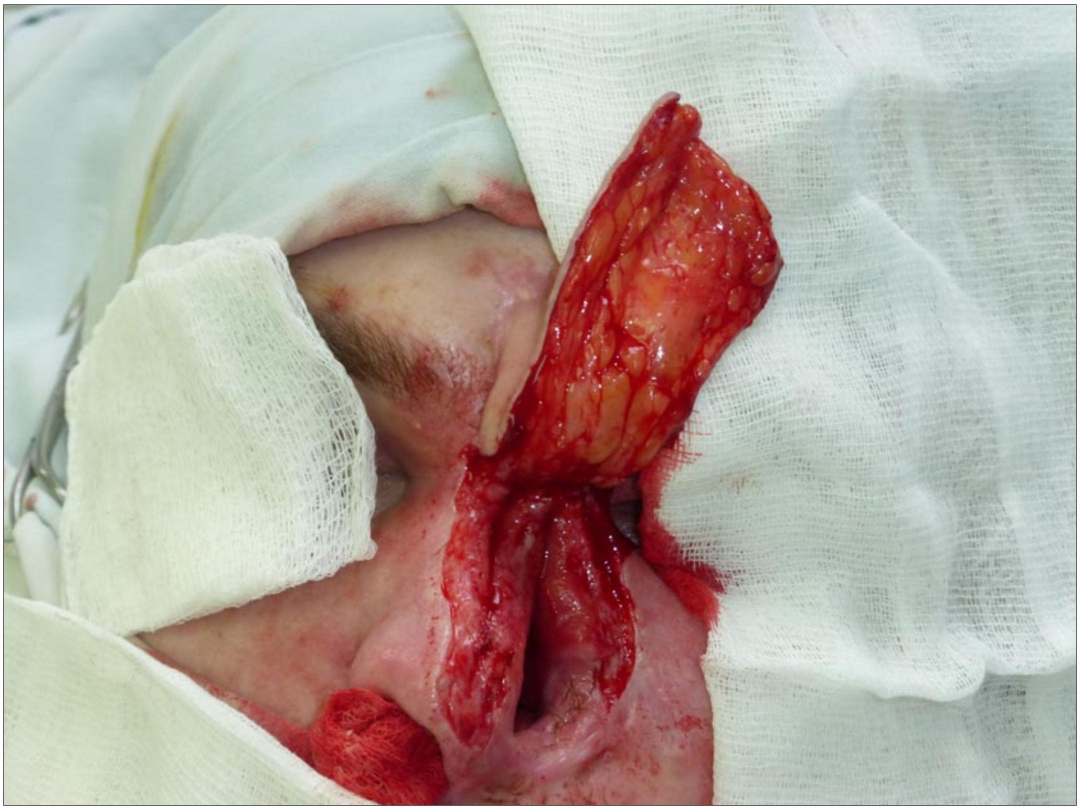


Figure 2.64. Adipo-cutaneous flap is opened from the tube

Figure 2.65. Patient’s nose is designed on the operating table

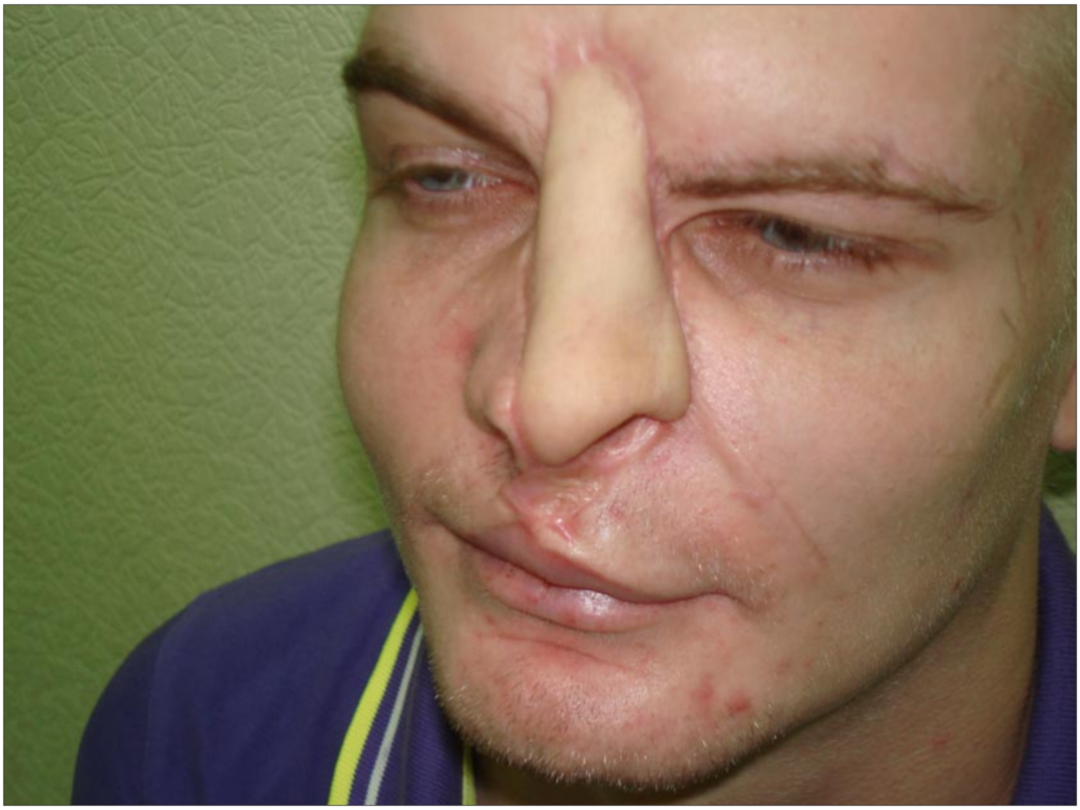


Figure 2.66. Results of one month treatment, correcting surgeries are indicated

In 2017 was one hundred year since the first publication of Professor V.P.Filatov describing skin plasty with the tubed pedicle, subsequently called the Filatov-Gillies plasty. Filatov's method was initially used for closure of the defect after removal of the lower lid. This method gave rise to different surgical fields. The technique was later modified. Various methods of pedicle and donor zone preparation were proposed; and new ways of pedicle transposition were described. Filatov stem or 'Russian plasty' has gained global acceptance and now is successfully used in various surgical fields. Advanced skin reconstructions are being developed and implemented. And though Filatov's method has many stages and more than 100 years history, it is still widely used in clinical practice. It is especially actual when resources of the local tissues are strictly limited, plasty with flaps on microvascular anastomosis is technically impossible, and flap size is not enough for Italian plasty, and also for radical repair of soft tissue defects or scars.

Tychinkina method

Antonina K. Tychinkina (1915-1970) was born in Kostromskoy region. In 1939 she graduated from Tomsk Medical Institute. During the Great Patriotic War she headed the Surgical Hospital. After the war she worked at Gorkovsky Institute of Reconstructive surgery. Since 1957 till 1963 - in Altaysk Medical Institution as an Associate Professor at the Departments of Faculty and Hospital Surgery. In 1963 Tychinkina was elected the Head of Generally Surgery Department at the Perm Medical Institute, where she worked for the rest of her life. In plastic surgery she is famous for her technique of full-thickness skin autografting with transplant buried on the donor's site.

Figure 2.67. Plasty with an adipo-cutaneous flap followed by bone plasty

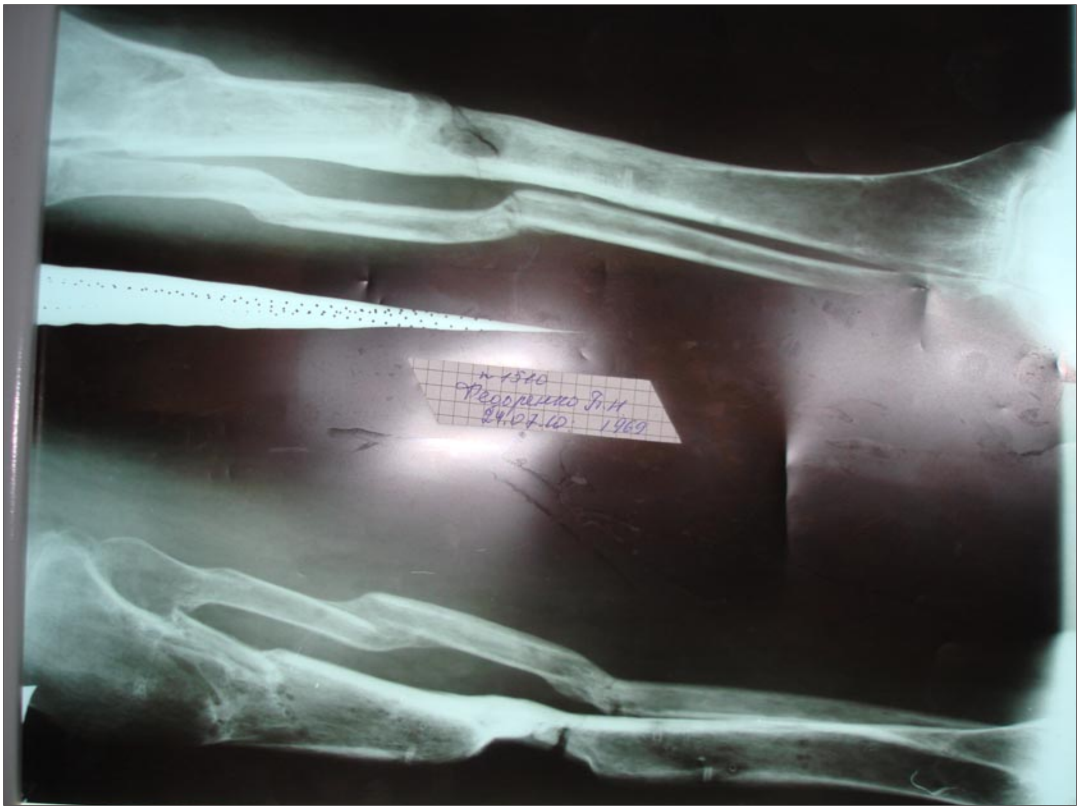


Figure 2.68. It is impossible to use a pedicle flap due to many traumas of vessels and scar tissue. Tychinkina's is indicated

Figure 2.69. Marking of the double pedicle flap on the opposite leg

Figure 2.70. Mobilization of adipo-cutaneous flap on the fascia followed by plasty using a split-thickness autodermotransplant with a thickness of 0,25 mm

Figure 2.71. Primary suturing, the donor site on the thigh

Figure 2.72. In 1 week, staged sharp training of the flap with primary suturing during 2-3 days

Figure 2.73. Adipo-cutaneous flap is viable in 2 weeks, the split-thickness graft survived on the fascia

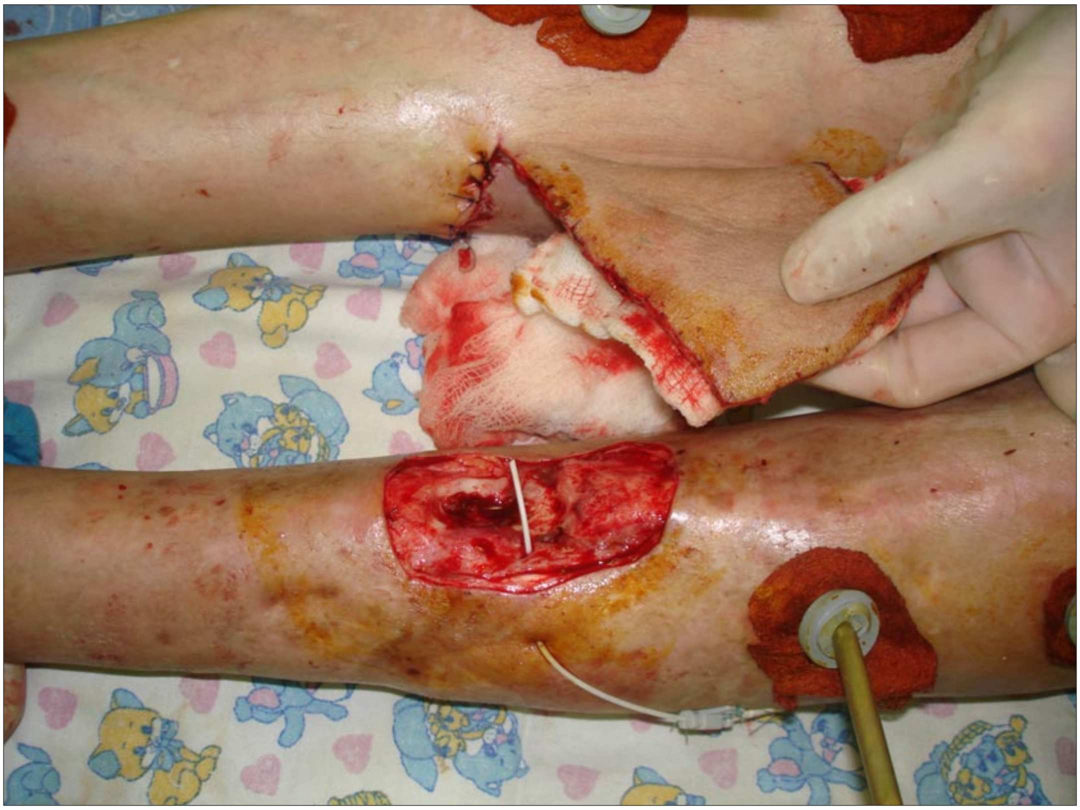


Figure 2.74. Scars and ulcers on the opposite leg are dissected

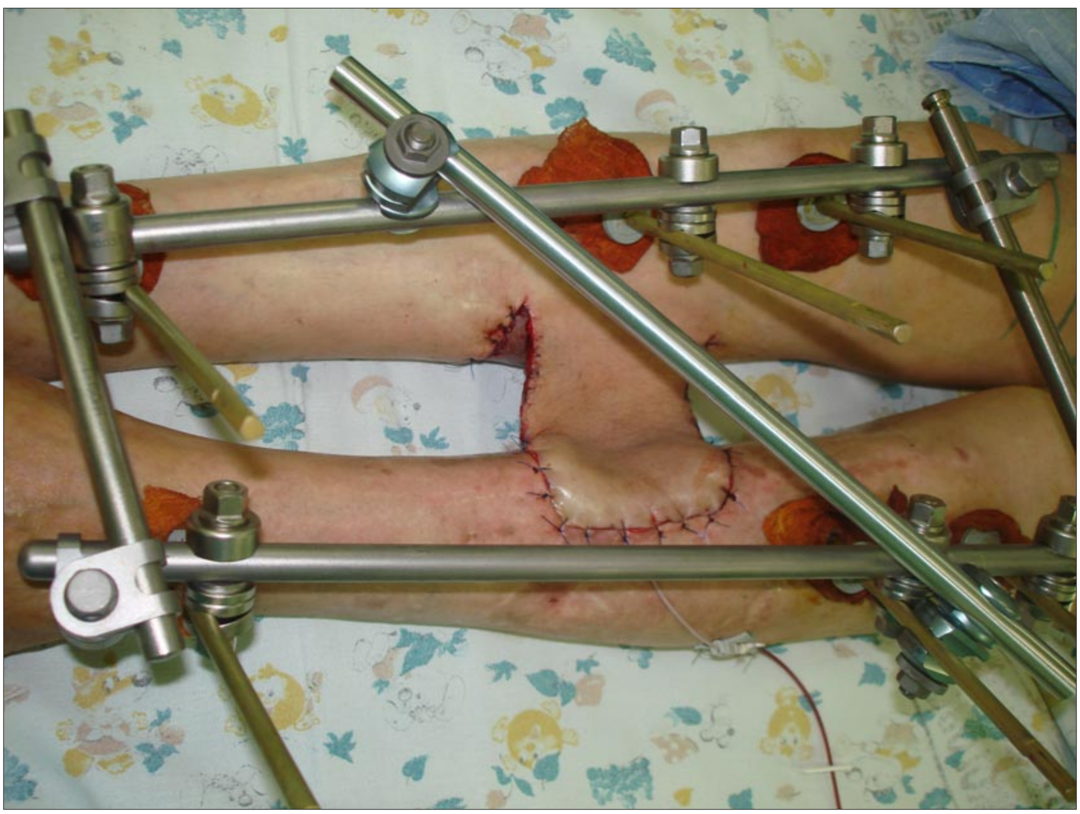


Figure 2.75. Monolateral external fixation apparatus is used after plasty for fixation

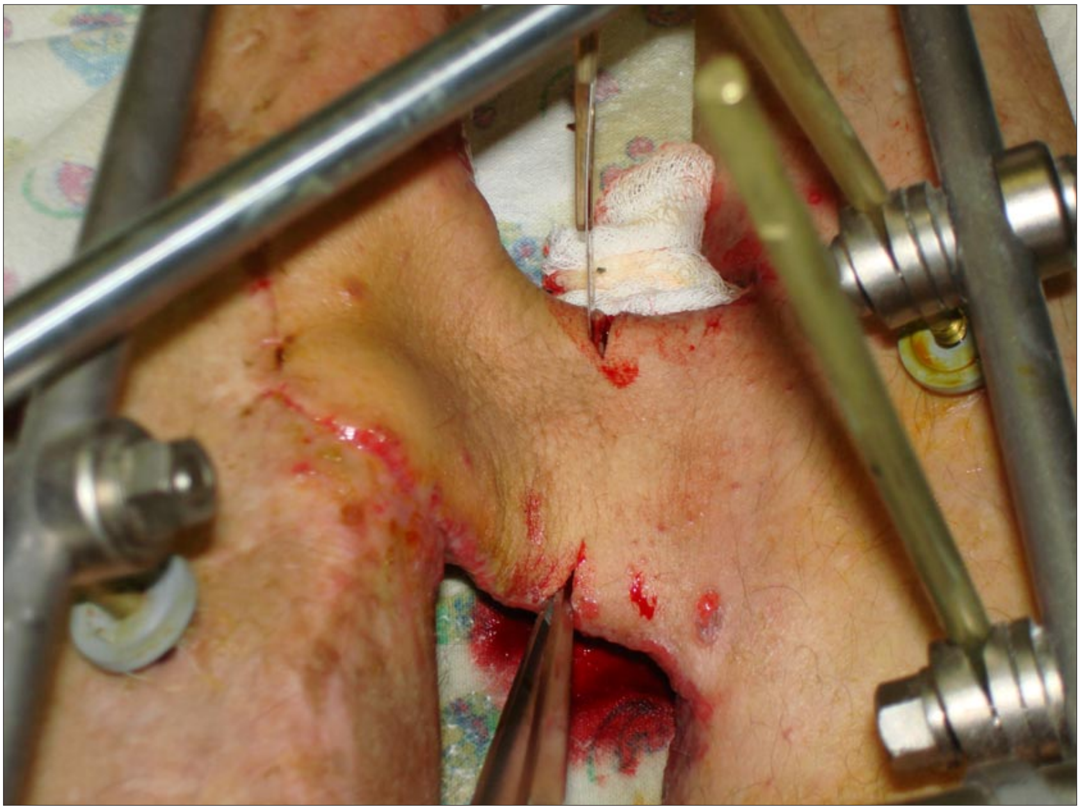


Figure 2.76. In 3 weeks staged dissection of the pedicle is performed within 2-3 days

Figure 2.77. Results of treatment, 1,5 months after the first surgery

Shimanovsky-Limberg method

Transposition of flaps create a zig zag line “harmonica”, which promotes In combustiology various scar contractures with different deformities are removed using local tissues, whereby, the defect is surgically converted to both trapezoidal and rhomboid pedicle flaps. Transposition of flaps creates a zig zag line “harmonica” that provides full motion in this segment. Plasty with transposition of rhomboid flaps is called after Limberg; and plasty with trapezoidal flaps – after Shimanovsky. Both methods are often combined for wound closure.

Yuly K. Shimanovsky (1829-1868) was born in Riga, worked at Derpskoe, Alexander University and the University of Saint Vladimir (Kiev). He is a pioneer of plastic surgery, famous Russian surgeon who contributed to the development of military surgery. He wrote the guidelines for military surgeons. He introduced and modified techniques of bone-plasty surgeries, modified the plaster cast. Shimanovsky offered the transplantation technique of process of ulna to the humerus split during amputations, and also the method of skin extension of amputation stump. He also introduced the way of closure of enterocutaneous fistula (Scimanovsky technique). He is the author of surgical instruments (resection saw).

In plastic surgery he is world famous for adipo-dermal pedicle flap harvested from the forehead using rhinoplasty. Plasty for closure of square defects using local tissues (trapezoidal plasty to remove scar contractures) is also widely used.

In 1865 Shimanovsky published the fundamental guidelines for plastic surgery "Operations on the surface of the human body".

Alexander A. Limberg (1894-1974). Soviet dental surgeon. In 1919 he graduated from Medical Military Academy. All his life he worked in Leningrad. Since 1924 till 1956 he headed the Dental Department in Leningrad Dentical Institution. He was the first in the USSR who described the advanced method of splinting in jaw fractures (1927). Limberg developed techniques of facial plasty with the pedicle flap. He proposed and implemented the original methods of bone plasty of the lower jaw, surgical treatment of cleft lip and palate.

His study “Mathematical principles of local plastic procedures on the surface of the human body”, wrote and published in Leningrad in 1946, was awarded the State Prize of the USSR. And the fundamental study “The Planning of Local Plastic Operations on the Body Surface” published in 1963 summarized his 40 years academic experience.

Local reconstructions using rhomboid pedicle flaps (after Limberg) have since been widely used in plastic surgery. More recently, facial plastic surgical techniques proposed by the author have been applied to various parts of the body.

Figure 2.78. Classical post-burn scar contractures

Figure 2.79. Trapezoidal and rhomboid flaps

Figure 2.80. Transposition of geometric s, contracture is removed

Figure 2.81. Post-burn scar contracture of the elbow joint

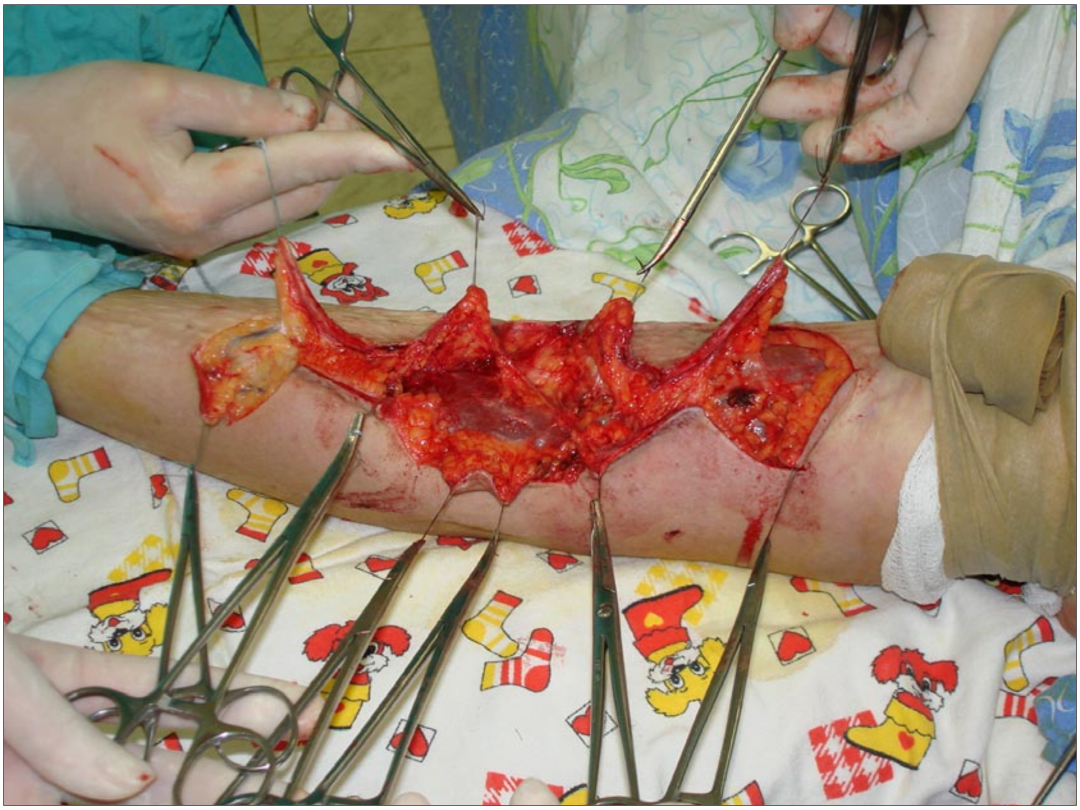


Figure 2.82. Trapezoidal one two couples of rhomboid flaps are formed under tourniquet

Figure 2.83. Contracture is removed, primary suturing

Rotation flap with regular pedicle:

Figure 2.84. Skin cancer of postaural area

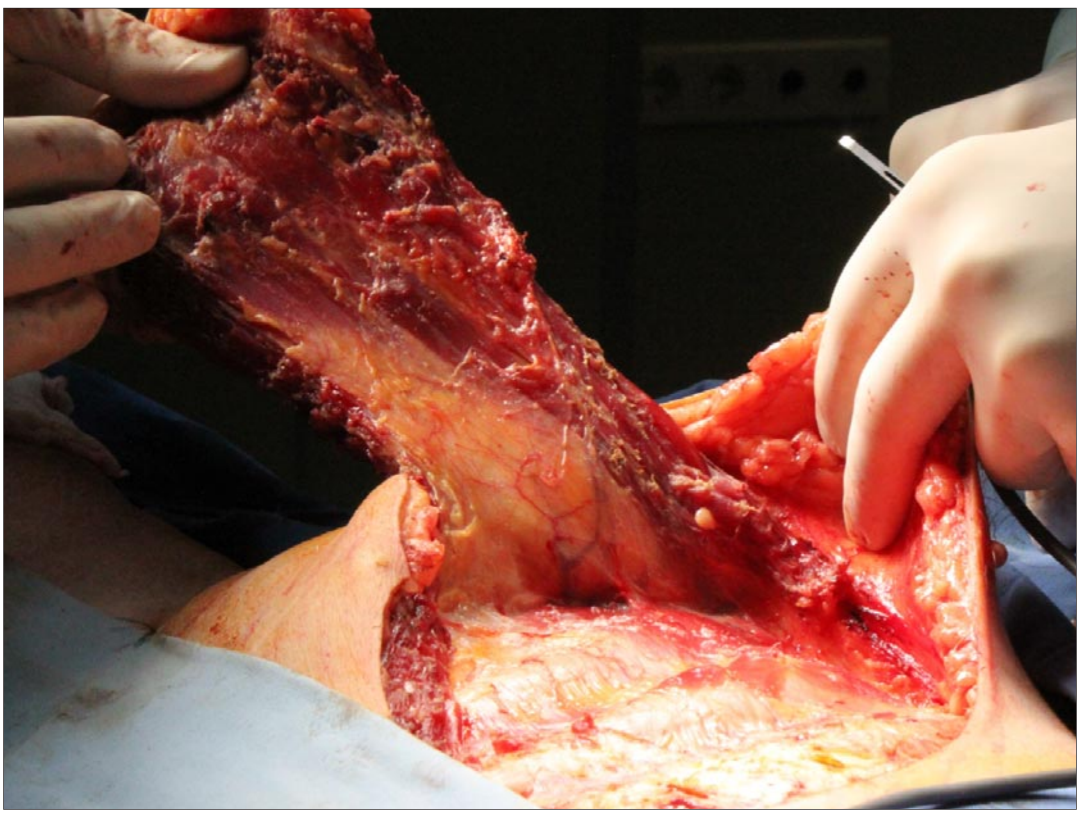


Figure 2.85. Musculo-cutaneous flap is formed on the chest

Figure 2.86. Plasty using a rotation flap with regular pedicle

Figure 2.87. Surgical results at day 7, the flap is absolutely viable

Figure 2.88. After car accident, dura defect, hernia formation

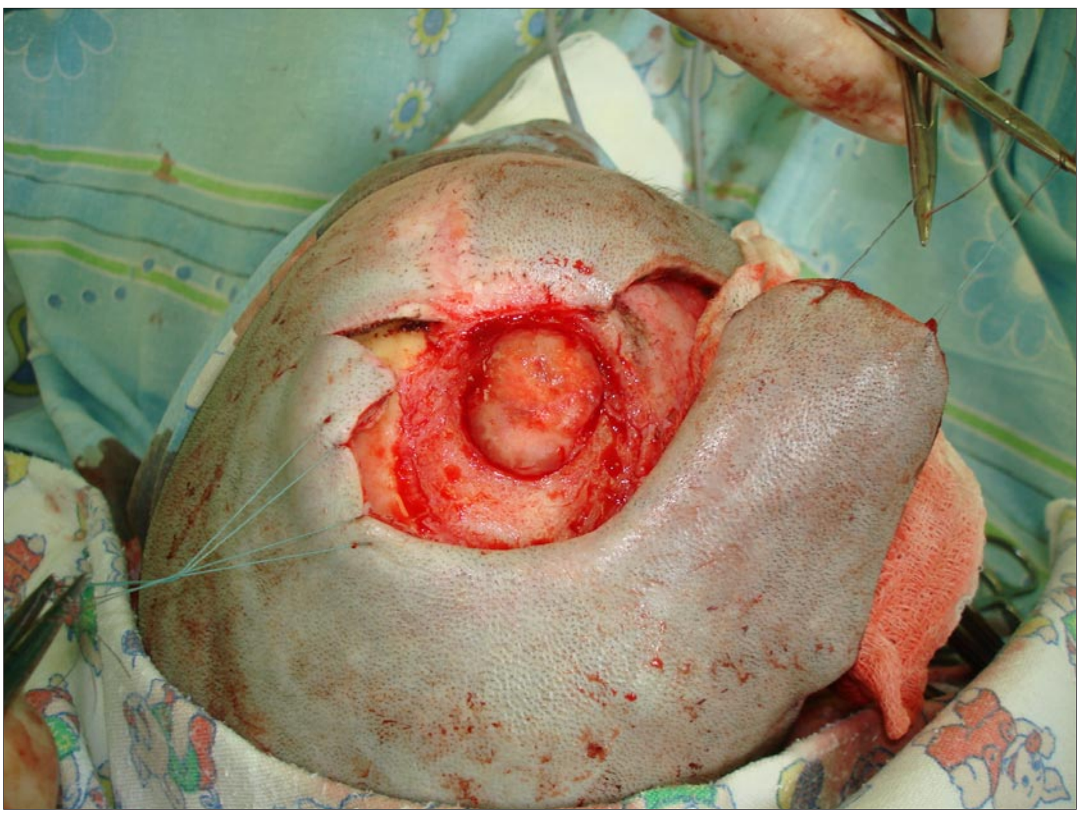


Figure 2.89. Excision of the injured dura, formation of rotation flaps

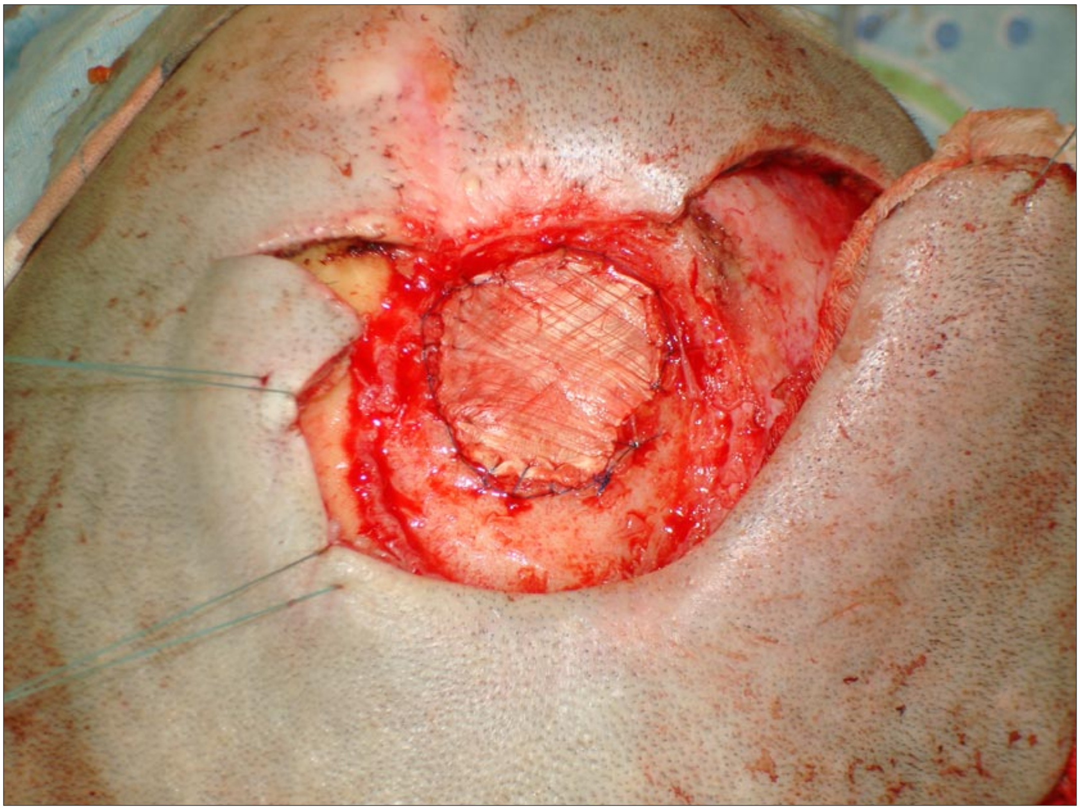


Figure 2.90. Plasty of dura using deep fascia of thigh

Figure 2.91. Dura wound is closed using the regular pedicled rotation flap, the donor site – using split autodermotransplant

Figure 2.92. Unsuccessful attempts of secondary suturing with many relaxation incisions on the nape

Figure 2.93. Osteonecrectomy using chisel

Figure 2.94. Given blood supply disturbance in local tissues due to relaxation incisions, the bone is covered with the double pedicle flap

Figure 2.95. Split-thickness autografting of the donor site

2.3. Distinguishing technical aspects of free and non-free skin autoplasty

Free split-thickness skin autografts should be taken from smooth areas which are easy to harvest (generally from anterior lateral parts of thighs). The donor site is coated with vaseline to make the dermatome slide more easily. It is important that transplant is uniform in thickness, and wound bed is smooth and has good blood supply. Using the lancet a surgeon creates several drain holes on the graft to provide the draining function, and the graft is perforated to increase its square. To prevent adherence of the graft to the dressing we put gauze wound dressings on the graft; then thick compression bandage, so that operative field is raised. The first dressing is changed in 3-5 days and we observe initial engraftment. When we use 0,2-0,3 mm grafts the donor site is epithelized under a wet-to-dry dressing (placed once immediately after the graft harvest) during 9-11 days. It is essential to preserve capillary blood flow in the subcutaneous fat of flaps when non-free skin autoplastic is performed. It is also important to save the structure of subcutaneous fat and its connection with dermis (does not trim off and does not divide into layers). A flap should be taken using traction sutures and avoiding folds at 90 degrees or more. Of particular importance is the ratio between the length and thickness of pedicle containing the blood supply. One-to-one ratio is considered optimal when blood supply is always proper for skin flap viability despite of the body part and type of pedicle (proximal or distal). In case of a long pedicle blood supply of the subcutaneous fat in this area is particularly important. Proximal pedicle is the best option. Dressings are changed every day. Blood supply of an entire flap is estimated in 5-7 days. Arterial problems occur in the first day, venous blood flow impairment - in 5-7 days. To improve the blood supply in addition to immobilization and positioning, patients receive vessel therapy, barotherapy, and physiotherapy (that improves both arterial and venous blood flow). Don’t put pressure dressings on a flap. If the blood flow in flaps is restored, they completely survive and wound healing requires from two weeks to two months. Then we make staging trainings or dissect the pedicle and model adipo-cutaneous flaps. Flaps become sensitive in 6 months, so flaps should be monitored and protected from traumas (burns, bed sores, callosities, freezing)

CHAPTER 3. COMBINED TYPES OF AUTOGRAFTING

To cover skin defects with or without open deep anatomical structures some researchers simultaneously use different types of free and non-free skin autoplasty. Different types of free and non-free autotransplantations were described in previous chapters.

Two clinical cases when the wound defect is simultaneously or sequentially (one on another) covered with combined plasty, depending on the anatomic features of different localizations, are presented in this chapter.

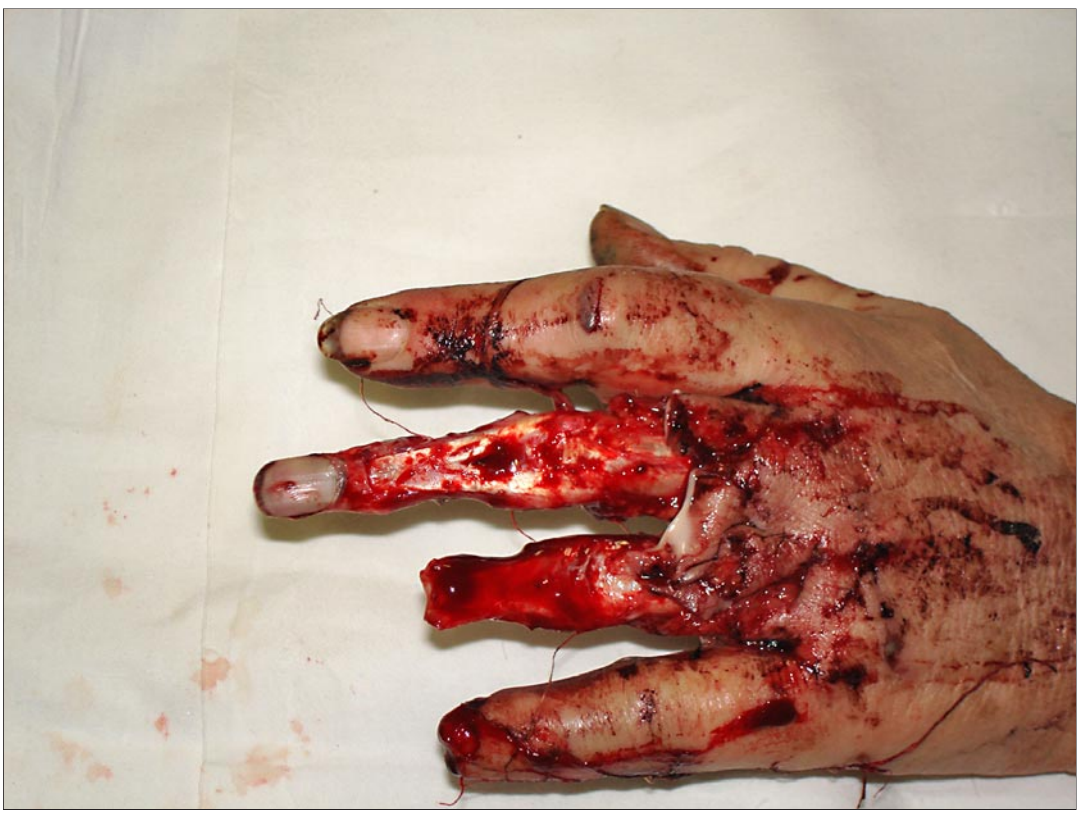


Figure 3.1. First hours after mechanical trauma (getting her ring caught), movement is completely restored

Figure 3.2. Circular exposure of tendons, adipo-cutaneous plasty is indicated to restore fingers

Figure 3.3. Radial flap based on a regular pedicle is formed

Figure 3.4. Free plasty using a split-thickness graft on the donor site, palm is closed with a radial flap

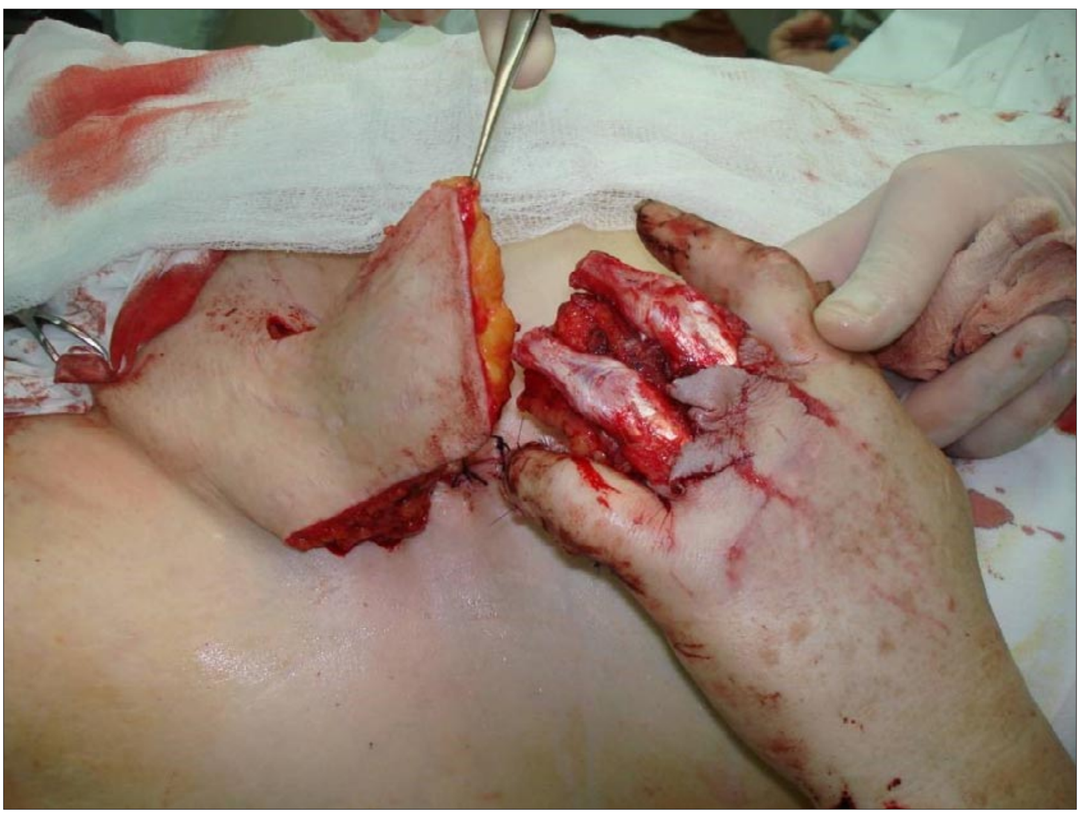


Figure 3.5. Italian plasty of the dorsum (left groin adipo-cutaneous flap)

Figure 3.6. Pedicle of the groin flap is dissected in 3 weeks; syndactyly is removed in 2 months

Figure 3.7. Fingers and hand functions are preserved, the patient is left-handed

Figure 3.8. One month after a car accident, necrosis of soft tissues with osteonecrosis, late admission to a specialized medical center

Figure 3.9. Necrectomy of soft tissues is performed at the first day, frontal sinuses and deep anatomical structures are exposed

Figure 3.10. Left blefarorrafia is performed to preserve the eye, wounds are cleared of fibrin

Figure 3.11. Osteonecrectomy and secvestrectomy in 5 days after the admission. There are vital indications for the wound closure

Figure 3.12. Free plasty is performed (as basis) previously to plasty with a pedicled greater omentum to the left facial vein and artery

Figure 3.13. Face lines and cavities are formed from the omentum

Figure 3.14. Omentum is reconstructed with a split-thickness autograft

Figure 3.15. In 2 weeks the omentum and grafts are viable

Figure 3.16. In 1,5 months blefarorrafia is removed, subcutaneous fat tissue of the omentum regresses

Figure 3.17. In 9 months reduced pigmentation, no edema, no indications for face transplantation, minor corrections are indicated

CHAPTER 4. DEVELOPMENT OF NEW TYPES OF SKIN AUTOPLASTY

4.1. Treatment of facial burns

Since face is particularly important both esthetically and functionally, the management of deep facial burns is still one of the main challenges in burn and reconstructive surgery. Deep facial burns are characterized by severe, coexisting traumas and high frequency of functional disorders. Facial scars are not only physical defects but also psychological trauma.

Most surgeons try to be very careful dealing with head, face and neck because of great esthetic and functional importance, almost always wait-and-see strategy is prevailing.

Single-staged excision of necrosis and plastic surgery with one autograft is preferred. However, such surgery on face is controversial for several reasons. Early necretomy is quite aggressive procedure; full removal of facial necrosis is difficult due to uneven skin texture. Only obvious necrosis has to be removed saving every millimeter of the living tissue. For these reasons, staged surgical treatment of face is preferred. However, active treatment strategy is known to result in fewer scars and lower mortality.

Reconstruction of skin defects including facial skin after burns is performed during the rehabilitation period and has three consecutive stages. Preventive rehabilitation (the first stage) is conducted in an acute traumatic period, while reconstructing the damaged skin. Optimal autografts and optimal time are crucial for maximum results in a long-term period. The second stage is conservative rehabilitation. It is administrated after wound epithelialization, includes physiotherapy, physical therapy and other types of conservative rehabilitation. If scar tissue formation on the patient's face is inevitable, surgical rehabilitation is administrated (the third stage). Both functional and esthetic surgeries are performed. The third stage is usually indicated within one year or a year and a half after the injury, when scars are 'mature' and surgery on raw scars cannot provoke scar regrowth. Early facial reconstructions are indicated only for severe functional defects. Surgical treatment of the face has many stages. A choice of an autograft is a matter of great importance. Free split-thickness autografts without perforation are optimal. Subsequently, however, reconstructed skin significantly differs from healthy facial skin. Moreover, secondary graft retraction occurs due to gradual regeneration of granulating tissue to scar tissue that affects facial expression right up to "mask effect".

0,5-0,7 cm is an optimal thickness of facial grafts. In a long-term period skin is stronger, not very different from intact skin, it demonstrates good elasticity and mobility with underlining tissue, risk of retraction is substantially lower. However, full-thickness grafts have such drawbacks as longer duration of surgery with manual graft harvesting, risk of incomplete survival because of a high level of metabolism, a limited choice of donor zones, inability to use one solid graft, slow engraftment within granulation tissue. According to many authors, full-thickness grafts cannot be used on the face at the moment. Recently proposed reconstructive techniques (skin transplantation, biosynthetic coverings, cell technologies) enable to regenerate skin which still differs structurally, esthetically or functionally from the intact one. Scar formation is an inevitable end point of human tissue repair.

By 2017 thirty three donor skin transplantations were performed in the world. Since 2015 Russia is in their list. Most patients have severe burn injuries. Transplantations are performed in a delayed post-injury period. The development of modern methods of facial plastic surgery in acute and long-term periods is still promising in combustiology.

4.2. Surgical treatment of skin burns using classical methods

A final goal of burn therapy is to restore skin integrity. This goal can be achieved only after surgical treatment of deep burns. Deep wounds demand skin autografting. Free skin autografting is used in burn departments all over the world when autografts are harvested with different dermatomes. Early necrectomy with primary or delayed plastic surgery is a gold standard of fast skin recovery; however, early necrectomy with primary autografting is not performed on the face. Staging necrectomy or early necrectomy is performed without primary surgery. In our opinion, following factors limit early necrectomy with primary facial plastic surgery: a) severe oedema of the soft tissues within first days after the burn followed by its reducing after the surgery, - the reason of retraction in an early post-operative period; b) stronger bleeding in this area can cause hematoma in a post-operative period.

c) uneven skin relief, it is difficult to put a pressure dressing on; d) usually more severe condition (intoxications produced by combustion products); e) electrical injuries and deep burns – conservative necrectomy of deep anatomical structures.

For large skin defects, with lack of donor sites and/or in order to provide wound drainage, autografts are perforated. However, with perforated autografts this method is not used in facial plastic surgery due to a mesh pattern in a post-operative period.

Thin split-thickness (thin) free skin autografts with a thickness of 0,2-0,5 mm without perforation are used in classical surgical approach. This method is very popular in Russia and all over the world. A surgery is performed within 14-30 days after injury on granulation tissue. Time period depends on readiness of granulations. Usually we need pink juicy granulations with print of a dressing after its removal without fibrin and purulent discharge.

Clinical case 4.2.1. Patient Z. (Figures 4.1-4.6) was admitted to our burn department the first day following 2nd-3d degree thermal burns of his face (flame) and extremities involving 17%. An extensive oedema of facial soft tissues and eschar formation began next day (Figure 4.1). Within three weeks after trauma the skin integrity of extremities was recovered. During three weeks staging necrectomy was performed on the face, granulation tissue developed and was ready for autografting without perforation (4.2). We used a free split skin autograft with a thickness of 0,3 mm with donor harvesting from the anterior-lateral part of the right thigh, grafts were fixed with an encircling stitch (Figures 4.3-4.4). This classical method demonstrates margin scars formation in the long-term period (Figures 4.5-4.6).

Figure 4.1. Soft tissue edema within two days after the injury

Figure 4.2. Granulation tissue before autoplasty

Figure 4.3. Plastic surgery with a non-perforated skin autograft

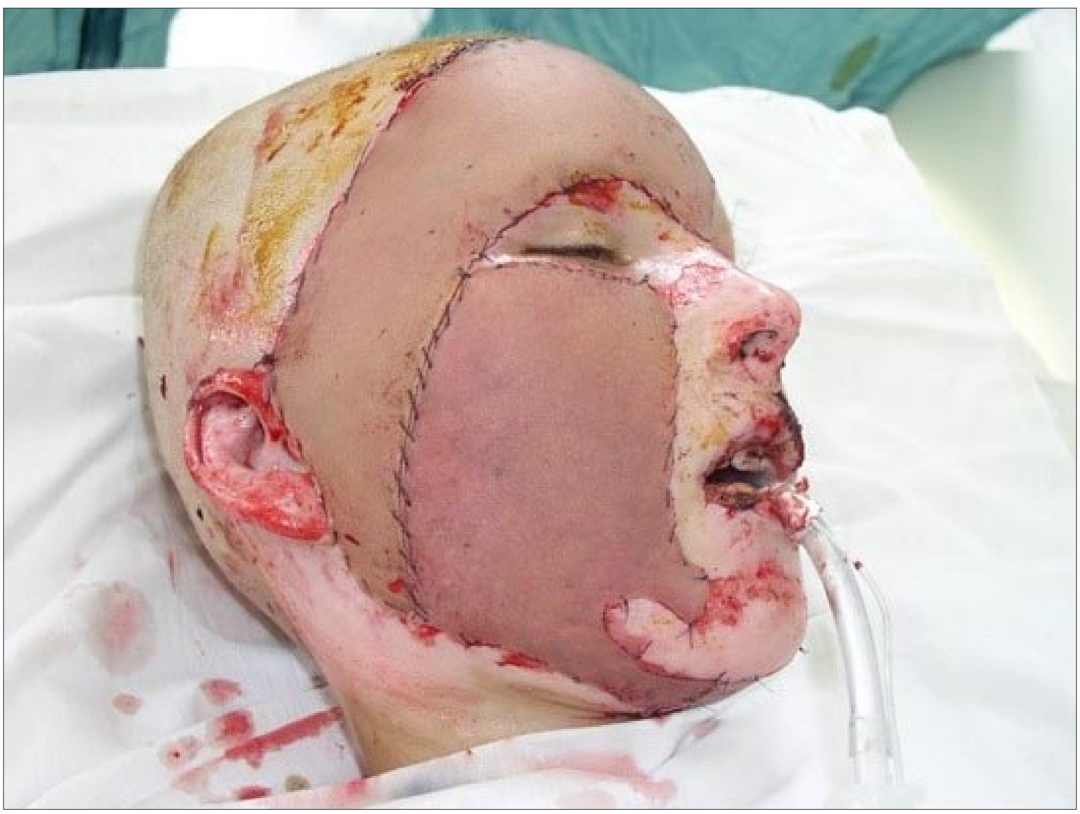


Figure 4.4. Encircling stitches are placed, then pressure dressings

Figure 4.5. Within six months the scar tissue appeared on the border

Figure 4.6. Rough boundary between grafts and healthy skin

Figure 4.7. Classical granulations within three weeks after the injury

Figure 4.8. Wound after plasty with non-perforated autodermograft

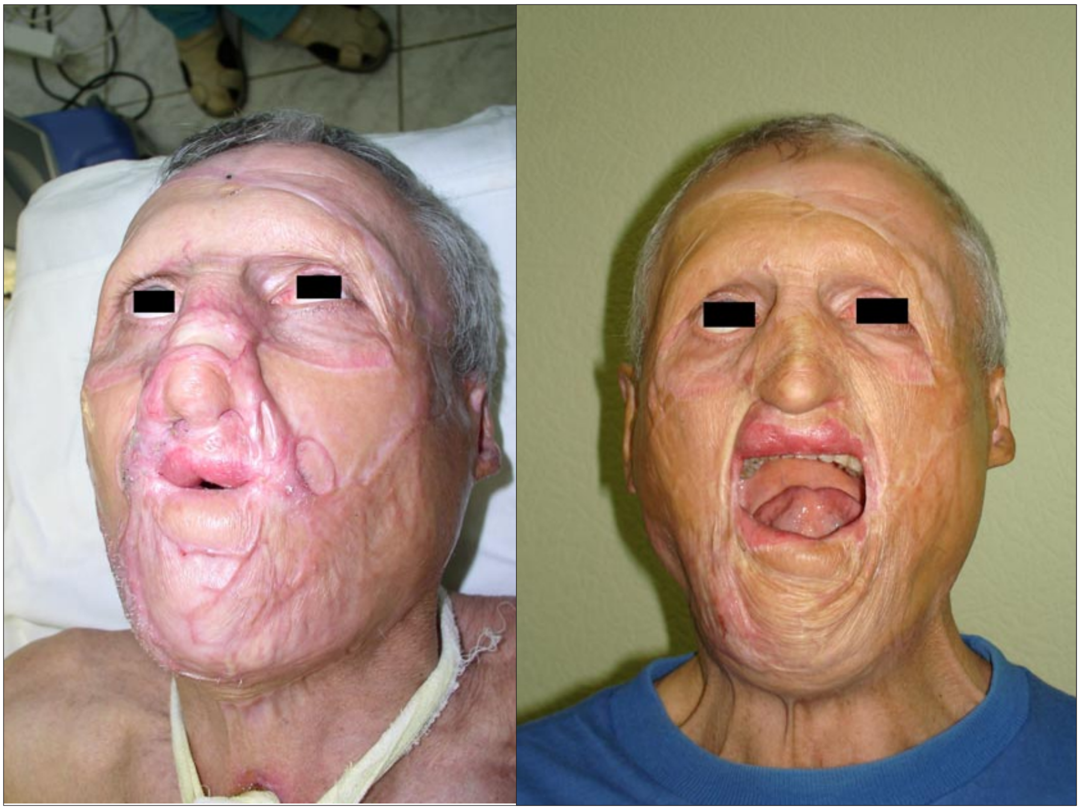


Figure 4.9–4.10. Scar contractions appeared in a year. Staged reconstructive surgeries are being performed

Clinical case 4.2.2. Patient S. (Figures 4.7-4.10) was admitted to our burn unit the first day following injury with 2nd-3d degree thermal burn of his face (flame), upper extremities and body involving 23%. As in the first case, granulation tissue developed within three weeks after the injury (Figure 4.7). We performed plastic surgery with split thickness autografs (Figure 4.8). All autografts completely survived. However, in long-term period scar tissue developed between autografts and healthy skin (Figure 4.9-4.10). Patient's skin also had tendency to scar tissue formation.

If the skin has a tendency to scar tissue formation and a patient is treated in the acute period according to all standards and demonstrates good results, in the long-term period ugly scars and deformations appear demanding long treatment and, the worst, they change a patient's life.

Clinical case 4.2.3. Patient S. (Figures 4.11-4.14) was admitted to our burn unit the first day following injury with 2nd-3d degree thermal burns of her face (flame), upper extremities and body involving 29%. As in the first two cases, granulation tissue developed within three weeks after the injury (Figure 4.7). We performed a plastic surgery with split-thickness autografts (Figure 4.12). They demonstrated good survival. We treated the patient according to the world standards for the treatment of deep facial burns. However, in long-term period ugly deformations appeared because the skin had tendency to scar tissue formation (Figures 4.13-4.14). These deformations demanded many reconstructive surgeries eliminating only functional defects; scars remained for life (Figure 4.15).

Figure 4.11. Granulations are ready for plastic surgery

Figure 4.12. Autodermografting without perforation

Figure 4.13. Tendency to the scar growth one year after surgery

Figure 4.14. Burns all over the face caused scarring

Figure 4.15. Many reconstructive surgeries are performed all life long

Therefore, in all cases we used classical method of treatment in acute post-injury period – plastic surgery with split-thickness skin autografts without perforation, according to the standard of burn care worldwide. Thereafter, we monitor patients and perform reconstructive surgeries if necessary.

4.3. Development of new methods for surgical treatment of facial burns

"To bring fresh vision to the problem and its solution directly or around. New ways of treatment give new possibilities to surgeons' hands..." Organizing committee of Prizvanie award 2014.

"Taking into account inevitability of scar tissue formation in a long-term period in patients operated by a classical method, analyzing long-term results and changes of life style after facial burns, inevitability of reconstructive surgeries, which only improve the appearance and do not eliminate scar deformations, all life long, - I thought how to solve all problems in an acute post-injury period". New technics of the surgical treatment aimed to solve these problems were created and modified. These new methods have been developed since 2000 stage by stage and, of course, when we see patients who undergone previous classical treatment we understand that now they would have been operated in other way using modern technics described in this chapter.

As you know, full-thickness (thick) skin autografts give better results than split-thickness (thin) skin autografts. However, it is believed, that a full-thickness autograft does not survive on a septic granulating wound. In 2000 it seemed for us impossible to use only one full-thickness skin graft. To create conditions for the survival of a full-thickness autograft and prevent scar growth on the face, we formulated main principles and technical tricks created step by step.

1 —To prevent scarring of wound margins we excise1-2 cm of margins, namely epithelized areas covered subsequently by scars. A parallel border of wound margins after the excision makes it possible to perform a burn surgery according to the plastic surgery standards: dermis to dermis, epidermis to epidermis.

2 —To prevent inner scarring we excise granulations.

3 —To prevent pigmentation and scarring of a split autograft plastic surgery with a full-thickness graft is necessary. For its survival, we excise granulations up to the lower fibrous layer of the granulation tissue.

4 —One solid graft harvested with a lancet excludes borders between grafts. The described examples demonstrate the development of new surgical techniques for patients with deep facial burns.

Figure 4.16. Hypergranulations one month after the injury

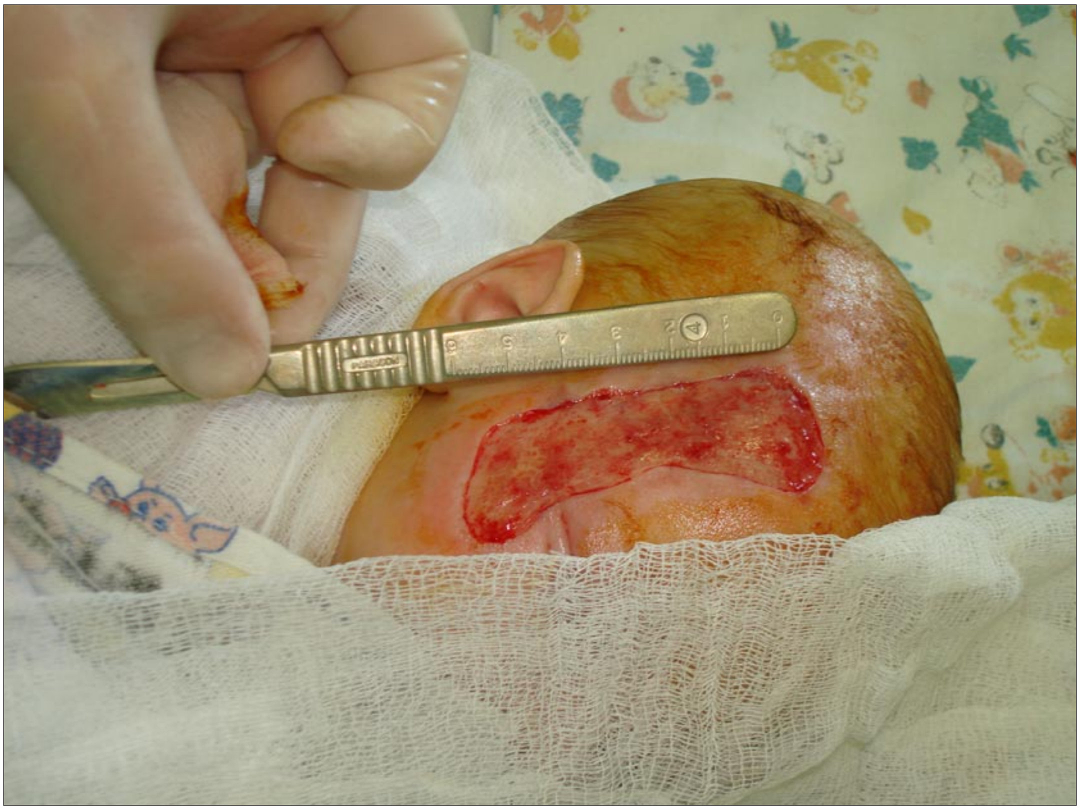


Figure 4.17. Granulations are dissected, autodermografting using 0,2 mm transplant

Figure 4.18. Grafts perfectly adapted. Patient before the discharge

Clinical case 4.3.1 Patient I. (Figures 4.16-4.18) was admitted to our burn unit 30 days following 3d degree thermal (contact) burns of his face involving 1%. Parents treated the child in a regional hospital and refused to admit him to our burn center for the surgical treatment. Finally, the child was referred to our center with hyper-granualtions which were excised before the surgery in order to improve skin survival (Figure 4.17). We performed a plastic surgery with autograft (0,3 mm). The autograft adapted well to the defect in a week, so the patient was discharged (Figure 4.18).

Clinical case 4.3.2. Patient S (Figures 4.19-4.25) was admitted to our burn unit 4 days following 3d degree thermal (contact) burns of his face involving 1%.An eschar was present on admission (Figure 4.19). The granulation tissue developed in 18 days (Figure 4.20). To prevent inner scaring we excised granulations. Wound margins were also excised. We made 0,5 cm incision with a scalpel from wound margins followed by excision of young epidermis (Figure 4.21). We performed a plastic surgery using an autograft with a thickness of 0,5 cm (Figure 4.22). The autograft adapted well to the defect, so 10 days after the surgery the patient was discharged (Figure 4.23). In later life scars did not appear (Figures 4.24-4.25).

Figure 4.19. Four days after the burn, formation of deep necrosis

Figure 4.20. Within 3 weeks necrosis disappears and granulations appear

Figure 4.21. Granulation are excised at the distance of 0,5 cm from the wound

Figure 4.22. Plastic surgery using a split-thickness skin autograft was performed

Figure 4.23. Graft perfectly adapted before the discharge

Figure 4.24. Scar tissue did not appear in a year

Figure 4.25. Staged necrectomies, clearance of necrosis

Clinical case 4.3.3. Patient K. (Figures 4.26-4.33) was admitted to our burn unit in the first day following with 2nd-3d degree thermal (flame) burns of his face, body and extremities involving 31%. An eschar was formed on admission (Figure 4.19). In 45 weeks (Figure 4.26) we noticed staged clearance from necrosis and formation of the granulation tissue (Figure 4.27). We excised granulations and wound margins to reduce scarring of the wound margins and inner area (Figure 4.28). To create optimal conditions for autograft survival we performed double blefarorrafia without blood. Then we conducted free skin autografting with a graft taken from patient's hips with thickness 0,3mm (Figure 4.29). The child was discharged in 2 two weeks. The autograft adapted well to the defect (Figure 4.30). There were no reconstructive surgeries in the long-term period, however, the transplanted skin differed from the healthy skin in colour and there were visible scar borders between grafts (Figures 4.31-4.33). The transplanted areas smoothed within 5-7 years. The excision of granulations and margins prevented scarring in the wound and on its margins; from the granulation tissue which is known as a portent of scar tissue.

Figure 4.26. No scars in 5 years, mild pigmentation of the graft

Figure 4.27. 25 days after the injury wounds are ready for surgery

Figure 4.28. Upper granulations and wound margins are excised

Figure 4.29. Autografting without perforation 0,3 mm

Figure 4.30. Grafts adapted in 2 weeks

Figure 4.31. All functions are fully restored in 2 years

Figure 4.32. Local scars of the upper lip and between the grafts

Figure 4.33. 7 years after the surgery, scars partially reduced

Clinical case 4.4.4 Patient P. (Figures 4.34-4.37) was admitted to our burn unit in the first day following the 2nd-3nd degree thermal (flame) burns of his face, body, extremities involving 52%. Closing deep burns of his body and extremities we performed a facial plastic surgery following excision of granulations and margins of deep burns one month after the injury (Figures 4.34-4.35). A graft was harvested from upper extremities, because lower extremities were severely injured and there was a lack of donor sites. In the long-term-period (Figure 4.36-4.37) reconstructive surgeries were not indicated, but despite good results split grafts differ in colour from healthy skin and there were remarkable scar borders between grafts. Within 3-5 years skin became relatively smooth and has reduced pigmentation.

Figure 4.34. Wound formation, excision of margins and granulations

Figure 4.35. Autodermoplasty using 0,3 mm thickness graft

Figure 4.36. Scars and pigmintated grafts are visible in half a year

Figure 4.37. In 5 years reduced scarring and pigmentation

Clinical case 4.4.5. Patient V. (Figures 4.39-4.45) was admitted to our burn unit in the first day following 2nd-3nd degree thermal (flame) burns of his face, body and extremities involving 2,5%. Within three weeks granulation tissue developed (Figure 4.38). To prevent scarring internally and on the margins we excised margins and upper layers of granulations described in previous clinical cases (Figure 4.39) To prevent graft retractions we performed a plastic surgery using a 1,5 mm full-thickness autograft. The autograft was cut with a dermatome (head DE -100, 10 cm wide, with maximal thickness of the gap 1,5 mm) (Figure 4.40). We harvested the graft up to the lower layers of the dermis; therefore, the plastic surgery using a split-thickness autograft with thickness 0,2 mm and perforation 1:4 taken from the patient's thigh, was required (Figure 4.41). We performed plasty with the full-thickness autograft and put encircling stitches, such stiches are usually romeved on day 5-7 (Figure 4.42). The autograft adapted slowly (Figure 4.43), but in the early long-term period scarring tissue did not develop (Figure 4.44), the colour of the grafted skin was close to the healthy skin colour, we did not observe retractions. In a year we achieved maximum functional and esthetic results.

Figure 4.38. Granulating wound is ready for autoplasty

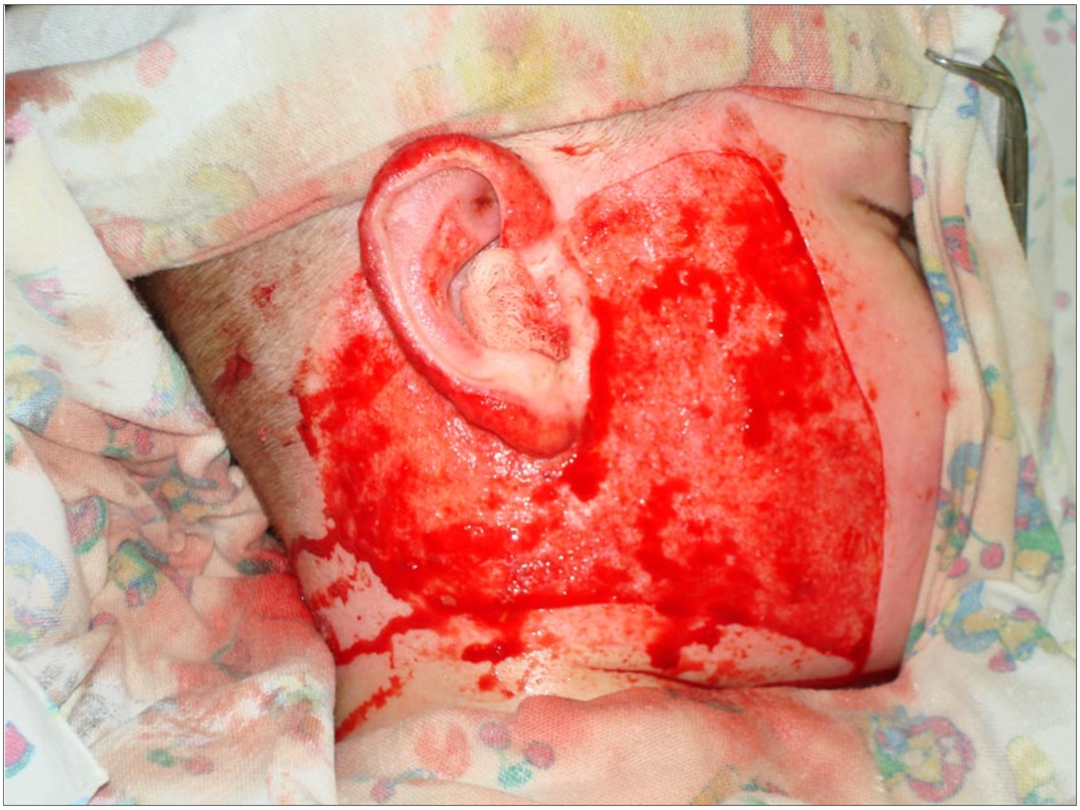


Figure 4.39. Excision of granulations and wound margins

Figure 4.40. Harvesting of a full-thickness graft with a thickness of 1,5mm using DE-100 dermatome

Figure 4.41. Plastic surgery of a donor site using a split-thickness skin autograft with perforation 1:4

Figure 4.42. Full-thickness graft transplantation with suturing

Figure 4.43. Slow graft adaptation in 8 days

Figure 4.44. No scars in 3 days, moderate pigmentation

Figure 4.45. Graft is close to healthy skin in a year

Clinical case 4.4.6. Patient R. (Figures 4.46-4.51) was admitted to our burn unit in a month following 2nd-3d degree thermal burns involving 1,5% caused by a scalding injury of his face. The child was on self-medication at home. His parents didn't seek medical treatment and used traditional medicine. On admission the patient had the wound with fibrin, mosaic epithelization, and purulent discharge.

Every day of the first week we changed dressings and noticed active epithelization, however, it was accompanied by epidermal ulceration. Given long post-traumatic period, late epithelization, which can be called the beginning of scarring – we decided to excise the wound and make a plastic surgery using one free full-thickness autograft,harvested with a dermatome (Figures 4.46-4.48). This full-thickness graft adapted in 12 days after the surgery.

View of the graft one month after the surgery (Figure 4.49). In 6 month scars appeared on borders of the plasty in the lower angle of the left cheek (Figure 4.50). Within a year and a half scars became less noticeable (Figure 4.51). We excised the wound together with weakened epidermis but we didn't excise burns at the lower angle of the wound because this area had strong epidermis. However this case demonstrates that epithelization formed in more than 15-17 days after an injury should be completely excised. Similar effect can be noticed on the upper lip of a child (case 4.3.3). (Within a month the wound epithelized, however, scar tissue formed on its place).

Figure 4.46. Mosaic epithelization and formation of granulations

Figure 4.47. Insufficient epidermis and granulations are dissected

Figure 4.48. Plastic surgery using a graft with a thickness of 1,5 mm

Figure 4.49. 1 month post-operatively, skin adaptation

Figure 4.50. No pigmentation in 6 months, however, the margin scar is visible

Figure 4.51. In 1,5 years scar reduces in the lower part of the left week

Clinical case 4.4.7. Patient Z. (Figures 4.52-4.61) was admitted to our burn unit the first day following second-third degree thermal burns (flame) on his face, body and extremities involving 28% of his body. In three days we noticed marked edema of soft tissues of the face and eschar formation (Figure 4.52). Within three days after the injury we started early surgical treatment of his body and extremities. Two weeks following the injury the granulation tissue began to appear on the patient's face (Figure 4.53).

Within 45 days granulation developed on the nose and eyes – this zone has tendency to scarring (Figure 4.54). The granulation tissue and wound margins were excised. Then we performed blepharorrhaphy, avoding bleeding (Figure 4.55). A 1,5 mm full-thickness graft was harvested from the patient's right thigh using a powered dermatome (DE-100) with a head 10 cm wide. This procedure was followed by the plastic surgery of the donor site using a graft to a thickness of 0,3 mm and perforation 1:4. We cut skin graft matching to the wound size and put stiches (Figures 4.56-4.57). We also put the pressure dressing to his face. In three days we changed the first dressing, stiches were removed on day 7 (Figure 4.58). In two weeks the patient was discharged, the graft adapted (Figure 4.59). In long-term period the granulation tissue didn't form and reconstructive procedures were not indicated (Figure 4.60). The colour of the thick skin matched to the healthy skin colour, so we achieved maximum cosmetic results (Figure 4.61).

Figure 4.52. Edema of soft tissues of the face, eschar formation

Figure 4.53. Staged necrosis clearance and granulation tissue formation

Figure 4.54. In 3,5 weeks the wound is ready for plasty

Figure 4.55. Granulations and wound margins are excised

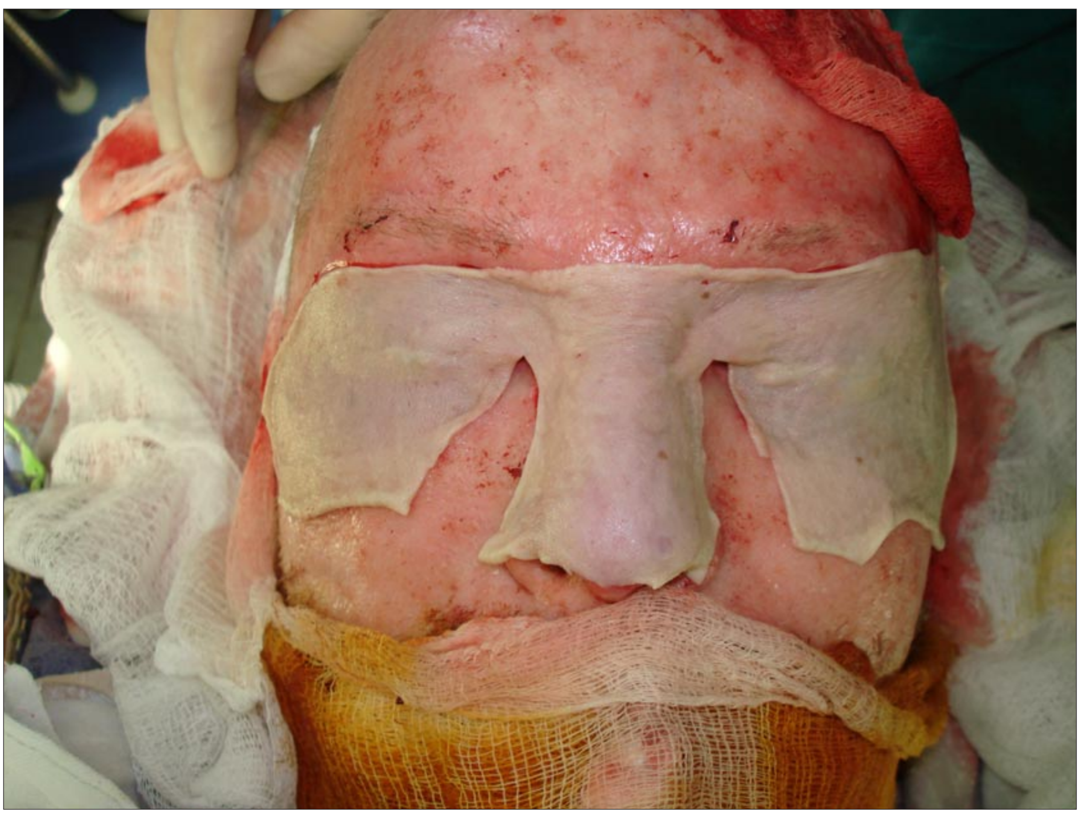


Figure 4.56. Stages of full-thickness facial plasty

Figure 4.57. Plasty using a full-thickness graft with suturing of margins

Figure 4.58. Mosaic isolated hematomas in 5 days

Figure 4.59. Two weeks after surgery before patient's discharge

Figure 4.60. Function is fully restored in a month

Figure 4.61. There are no scars in year, eyelids movement is not constricted

Clinical case 4.4.8 Patient Sh. (4.62-4.80) was admitted to our burn unit the first day following the injury with thermal burn (flame) of his face 48%II-III stage, upper airways burns, deep burn shock (4.62-4.63). Within one month skin was repaired on extremities and the body (4.64-4.65). We planned to perform facial plastic surgery with full-thickness autograft, so we left healthy skin site on patient's abdomen for donor harvesting. Surgical treatment of deep facial burn included following procedures. The wound was cleaned from necrosis (eschar). 3 week following the trauma and granulation tissue formation we prepared the surgical site according to all standards (4.66).

We excised 1-2 cm of the upper and middle granulation tissue using a dermatome and scalpel and reached the lower layers (till fibrous layer) without exposure of the subcateneous tissue (4.67). Hemostasis was achieved by pressing the wound with a dressing containing adrenaline solution for 3-5 minutes (4.68-4.69). Coagulation was performed only for large vessels (4.70). Using a scalpel we made a bordering incision perpendicular to skin in the distance of 0,5-2 cm from the wound to healthy skin,. Therefore, we limited possible scarring on the margins from areas of margin epithelization. After that using the scalpel we formed a border between the graft and healthy skin excising wound angles. This technique enables to perform the procedure according to the standards of plastic surgery: dermis to dermis, epidermis to epidermis

Figure 4.62. Formation of dry necrosis 3 days after the burn

Figure 4.63. Deep burn wounds involving 48% of child's body, IT trauma

Figure 4.64. Early necrectomy using delayed simultaneous transplantation with auto-skin graft

Figure 4.65. Skin of the extremities is restored firstly

Figure 4.66. Granulations are ready for autografting

Figure 4.67. Granulations and wound margins are excised

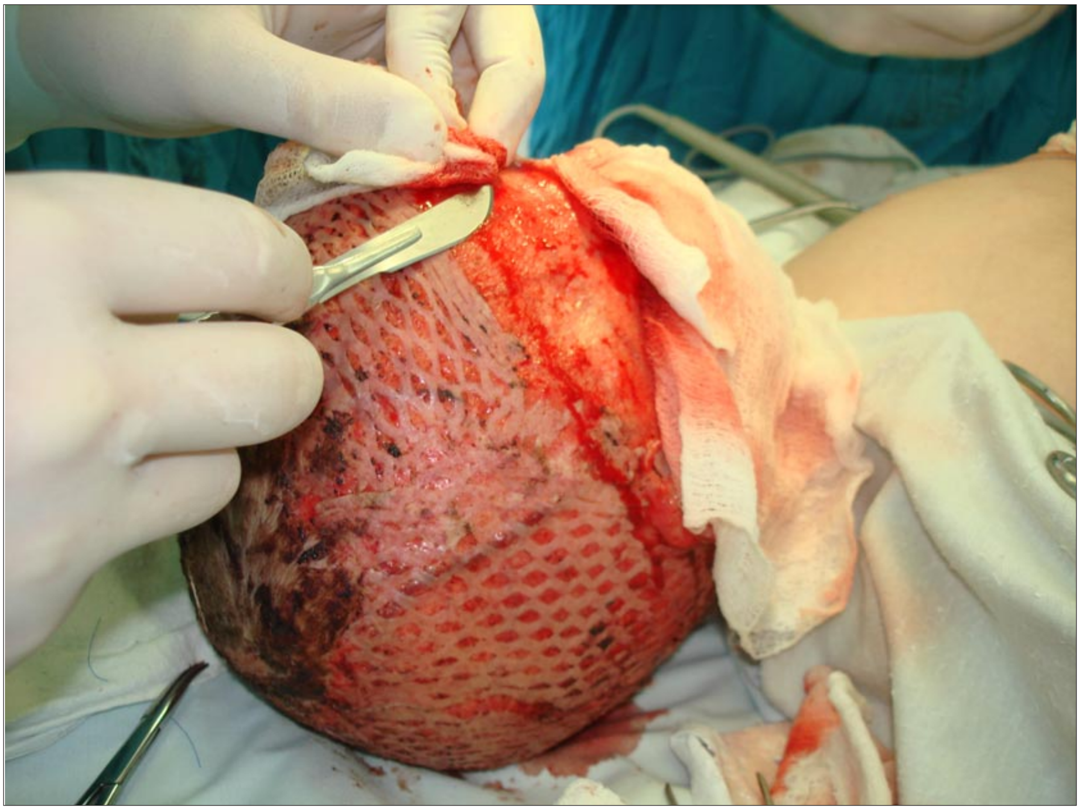


Figure 4.68. Upper layers of granulations were excised using a scalpel

Figure 4.69. Hemostasis using diluted adrenaline solution

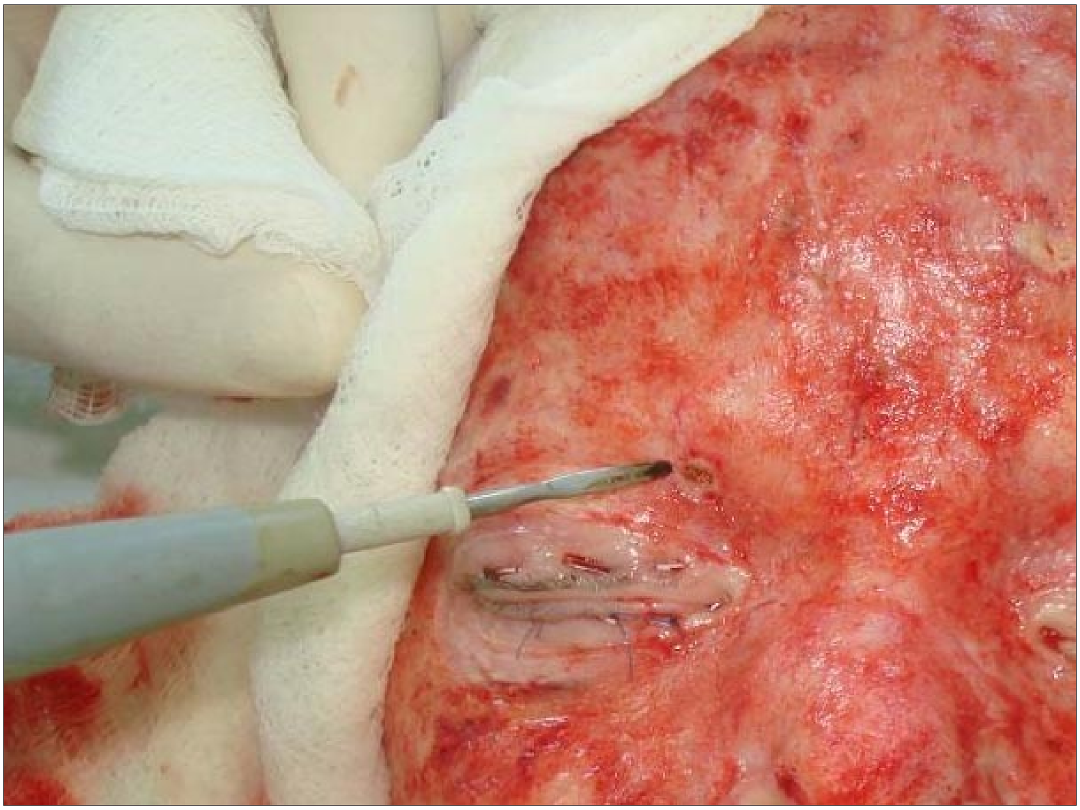


Figure 4.70. There is no scar tissue due to one full-thickness autograft

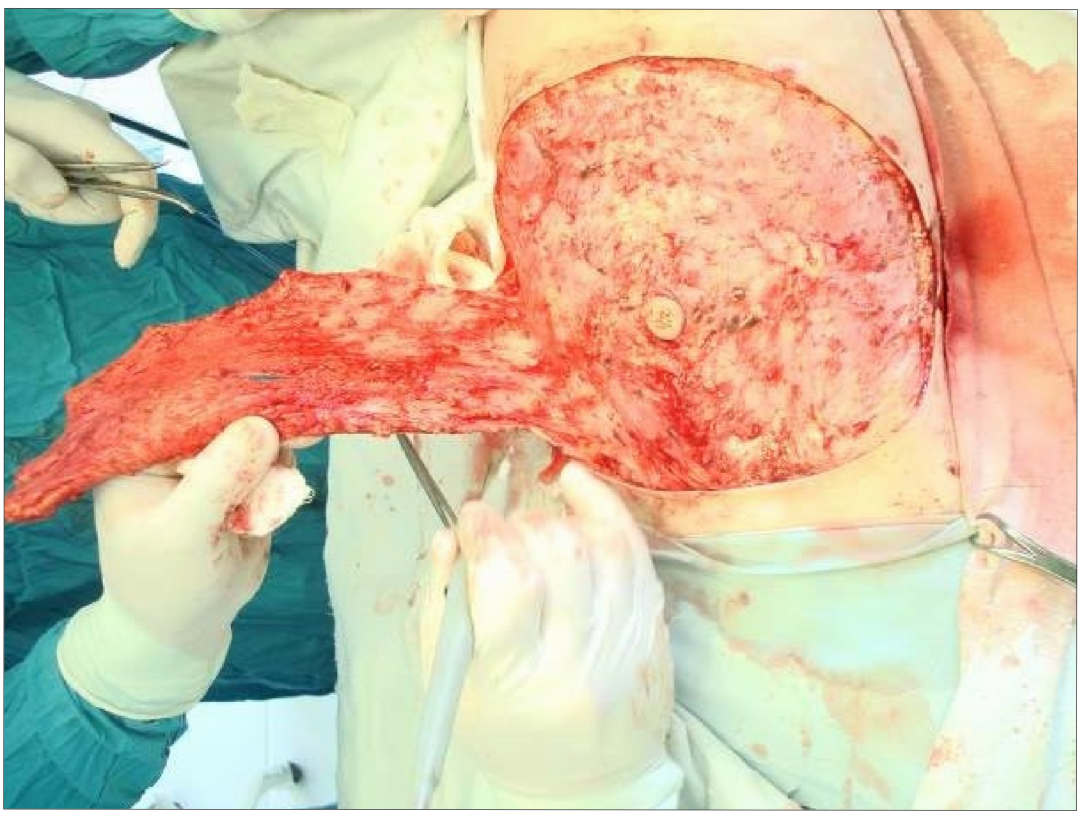


Figure 4.71. Harvesting of a full-thickness skin autotransplant

We measured the wound and made the equal incision on the interior surface of the abdomen using a scalpel (Figure 4.71). Skin graft was taken on the traction sutures and excised with upper areas of the subcutaneous tissue. Internally, we excised subcateneous tissue of the graft using scissors and 0,1mm of the graft dermis was smoothed with a dermatome from inside (Figures 4.72-4.73). The thickness of graft was 1,5 mm. Then we performed a plastic surgery with a free full-thickness skin graft (Figures 4.74-4.75).

We formed spaces for a mouth, nasal passages, eyes in the full-thickness graft (Figure 4.76). In 7 days, provided the granulation tissue formation on the donor site, free split-skin autografts 0,2-0,3 mm in thickness were harvested from free skin areas with a powered dermatome, perforated 1:2 and placed on the granulation wound of the donor site of the full-thickness skin graft. Section 4.4 is devoted to the treatment of the donor site.

The engraftment of the full-thickness skin transplant at day 9 following the surgery is presented on Figure 4.77. The graft adapted slowly. Within first three months the graft was prone to contraction but 6 months following the surgery it was soft and without scars. Despite the reconstruction with one free full-thickness skin graft, we achieved maximum results not only functional but also esthetical (Figure 4.78-4.80).

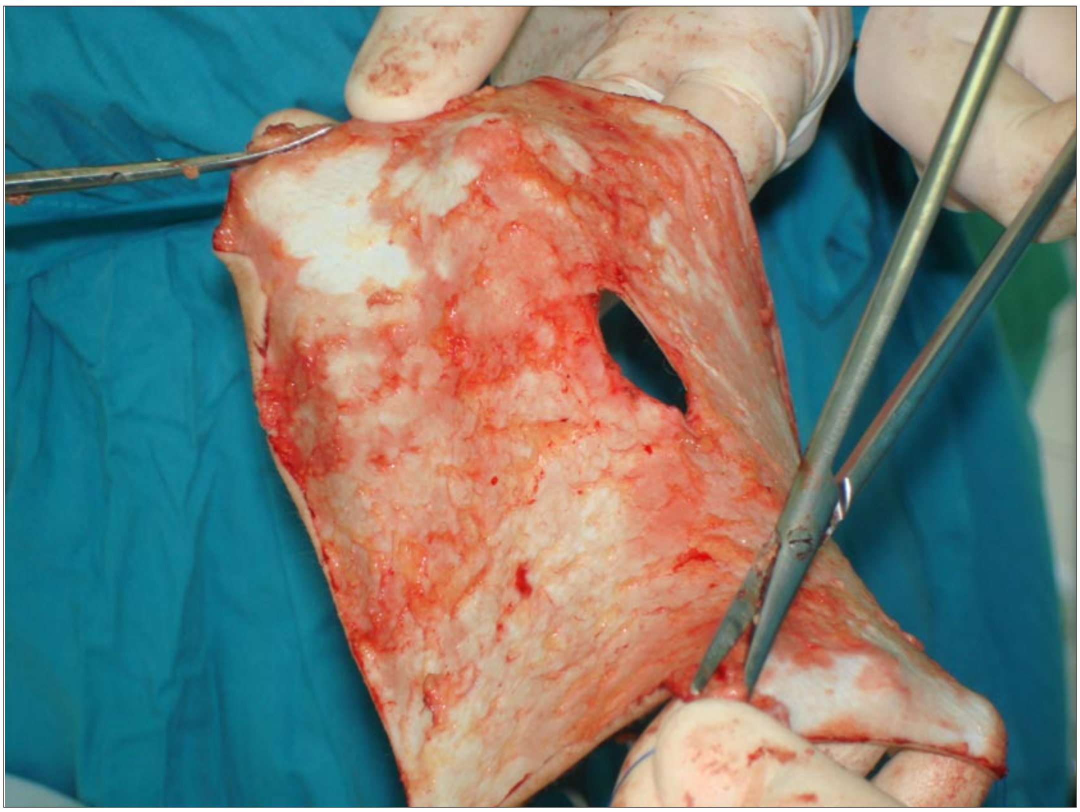


Figure 4.72. Excision of subcutaneous fat tissue with scissors

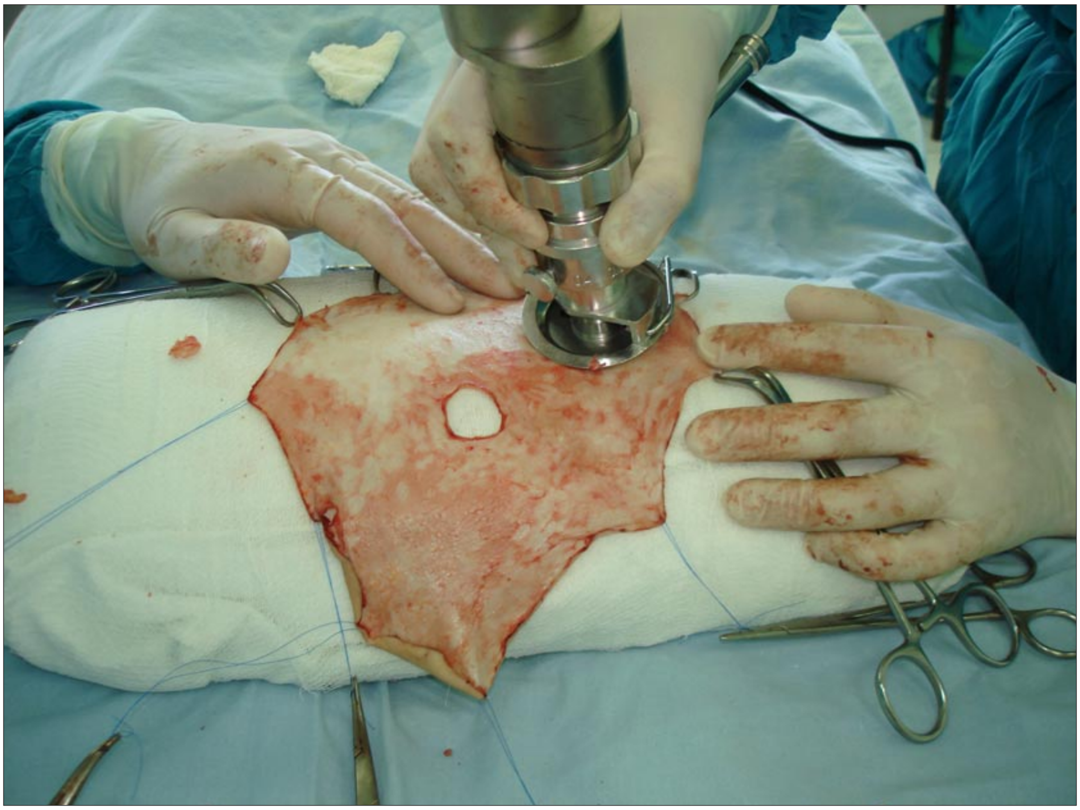


Figure 4.73. Lower layers of dermis were smoothed internally

Figure 4.74. Plasty using one full-thickness skin autograft

Figure 4.75. Stages of 7-hours long surgery, ALV through a tracheostomy tube

Figure 4.76. Surgical results – plasty of the facial skin

Figure 4.77. The graft adapted slowly within the first week

Figure 4.78. One month post-operatively, before the discharge

Figure 4.79. No scar tissue in a year

Figure 4.80. No scar tissue due to one full-thickness skin autograft

Clinical case 4.4.9 (4.81-4.90). Stages of treatment and skin plasty using one full-thickness autograft.

Figure 4.81. Eschar at day 5 after the burn

Figure 4.82. Granulations are formed in 3 weeks

Figure 4.83. Wound one month after excision of granulations and margins

Figure 4.84. The first facial plasty using one full-thickness autograft according to our method (April 23, 2010)

Figure 4.85. Suturing «dermis to dermis, epidermis to epidermis»

Figure 4.86. Results of the first surgery using one full-thickness graft according to the proposed method

Figure 4.87. Slow graft adaptation 2 weeks post-operatively

Figure 4.88. Microstomy is removed in 6 months after the burn

Figure 4.89. No scar tissue in a year, the full-thickness graft seems scarcely different from healthy skin, freckles are visible

Figure 4.90. Wound before plasty, after excision of margins and granulations

Clinical case 4.4.10. (4.91-4.95).

Figure 4.91. Growth of granulation wound one month after the injury

Figure 4.92. Before plasty, after excision of granulations and margins

Figure 4.93. Surgical results of our technique

Figure 4.94. Treatment results 2 months after the discharge

Three weeks post-operatively the patient was discharged. Long-term postoperative results are shown on Figures 4.94-4.95. The granulation tissue was observed on nasolabial triangle. Unlike grafted full-thickness skin, which is soft and without scars, it matches the colour of normal skin. This case demonstrates that full-thickness free autografting demands excision of all burns with epithelization later than 15-17 days following the injury.

Figure 4.95. Scar tissue in non-operated zones in 8 months

Clinical case 4.4.11. Patient D. 20 years (Figures 4.97-4.107) from the former Soviet Union was injured when he was 6 months old. He did not get medical care during 19 years because of its absence and/or it was very expensive. The patient suffered from deep psychological trauma and was afraid to look at the mirror.

Being motivated to the facial plasty he with his relatives asked for help in Russia through Internet. The patient was invited to "Live programme about plastic surgery" on the first Russian channel (dated 19.02.2016 – Internet archive).

There the patient made an acquaintance with other patients who had been treated in Krasnodar burn center and operated on their faces during acute period of the burn injury with one full-thickness skin graft. The patient chose this type of transplantation in order to eliminate at once all scar deformities. At first we addressed different technical aspects and stages of the surgery, because this surgery is exclusive.

Within 6 months the patient acquired Russian citizenship and insurance, so he could be treated free of charge. 14 and 7 days before surgical treatment the patient donated 500 ml of his blood for supposed auto-hemotransfusion. At first we performed dilatational tracheostomy.

We marked the supposed area of the scar tissue excision 22 X 27 cm. First of all we removed upper and lower eyelid eversion, formed trapezoidal s from the soft tissue in outer and inner angles of the eyes.

Figure 4.96. Multiple 19 years old scar deformities of the face

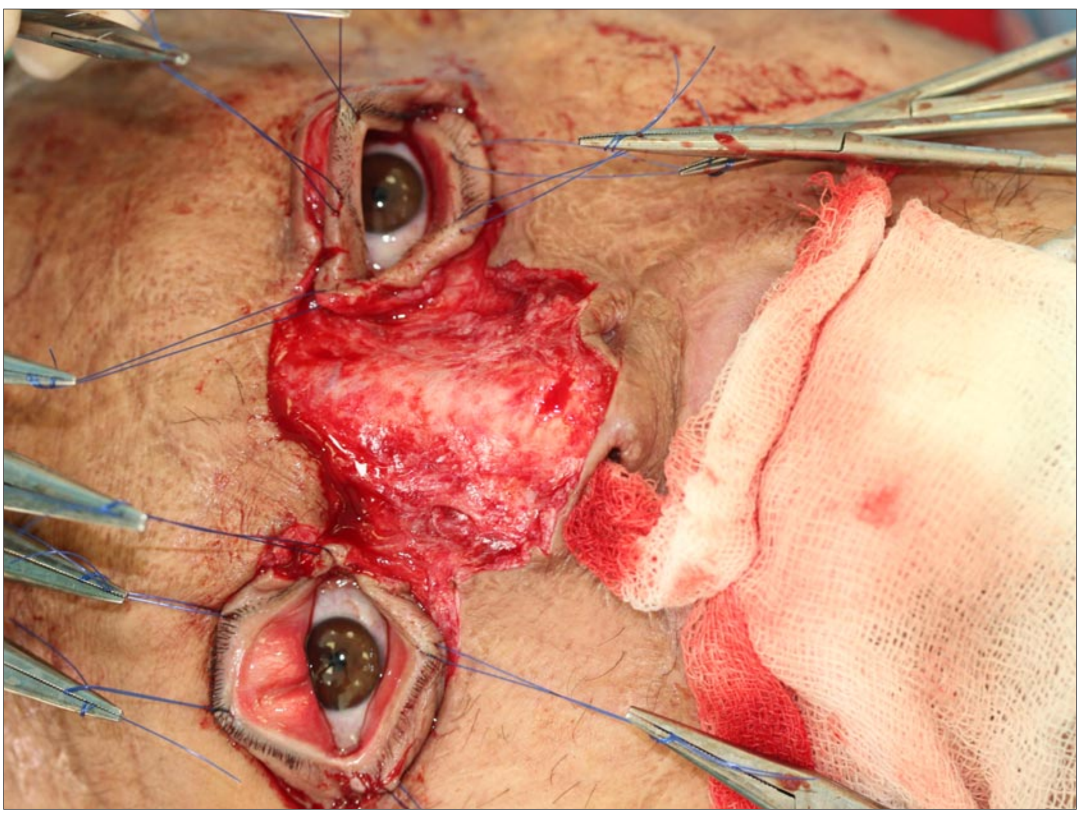


Figure 4.97. Staged scar excision, removal of lid eversion

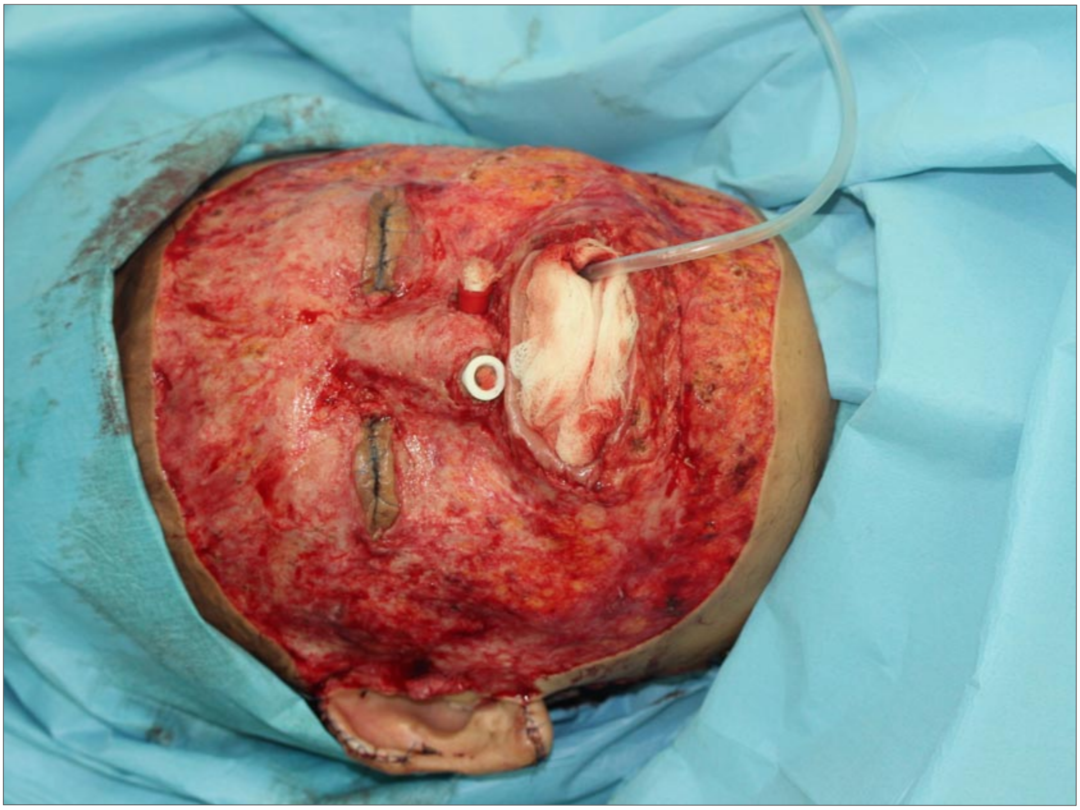


Figure 4.98. Face after scar excision and removal of deformities

Figure 4.99. Harvesting of a full-thickness graft from the abdomen and its preparation according to the described techniques, followed by autoplasty

Figure 4.100. Performing plastics with one full-layer autograft

Figure 4.101. Result of 13,5 hours surgery

We excised the scar tissue by areas, if there would have been blood losses we had reduced the volume of the surgery. Only for major vessels we used hot adrenaline solution and punctual coagulation for hemostatis. We removed upper and lower lips eversion, performed bilateral microstomy, gathered nasal passages, excised scars of his left external ear followed by ear formation, and excised all facial scars. Hemostasis was achieved. After that we harvested a full-thickness skin graft 22x27 cm from the patient's right abdomen. We put a vacuum dressing on the donor wound. Firstly, we removed the subcutaneous tissue from the full-thickness graft using scissors. Secondly, we excised dermis and matched the graft bed with the dermatome. The thickness of the graft was 1-1,5 mm. Then we performed facial plasty with the full-thickness skin autograft, made eyes, nose and mouth holes, put stiches.

To provide uniform pressure we put the vacuum dressing on the head. After surgical manipulations on the head, wounds were bandaged tightly 2-3 times using Kerlix AMD. After that the patient's head was covered with a special sterile bag for vacuum system Suprasorb CNP Easy Dress, the bag was fixed with Suprasorb E, and then we made drainage hole in the dressing, and connected the vacuum device with appropriate parameters through a drainage-connector. The vacuum dressing was taken off in two days. We noticed uniform pressure on the graft after its removal. The patient was transferred to prolonged ALV.

The graft adaptation was slow because the graft was thick, however, it completely adapted at day 17. While planning the surgery the important task was to prevent blood losses. So during the surgery we made auto-hemotrasnfusion of 500 ml of packed red cells and 500 ml auto-plasmotransfusion. Hemoglobin level before surgery was 132 g/l, and 118 g/l after surgery. We prepared but didn't use a cell saver because of pinpoint bleeding. Scars were excised using only a scalpel with hemostasis of every square cm.

6 surgeons operated the patient for 13,5 hours with simultaneous graft harvesting and its preparing for 3 hours. Clinically we observed more slowly adaptation of the full-thickness graft comparing with split-thickness graft, with its possible cyanosis caused by capillary growth.

Figure 4.102. Vacuum dressings on the donor site and the head

Figure 4.103. First dressing is changed in 2 days, uniform pressure on the graft, tamponade of the nasal cavity, mouth

Figure 4.104. Full-thickness autograft adapts slowly

Figure 4.105. 17 days post-operatively, «first impressions»

Figure 4.106. Before the discharge, the patient is pleased with treatment results

Figure 4.107. 9 months post-operatively, no post-scarring treatment

In 17 days the patient and his relatives saw the surgical results. We achieved two goals: 1-removed all scar deformities; 2 excised all facial scars and made the plasty with one full-thickness skin autograft. 1,5 months after the surgery the patient was discharged. He was pleased with his new long-expected face.

Treatment of scars was not necessary after the surgery. However, the scar tissue did not form because we used one full-thickness skin graft. We achieved maximum functional and esthetic results. The patient was satisfied. He changed his lifestyle. He is no more an anchoret, he received job and wants to start a family. In our opinion this method is a good alternative to the facial transplantation that allows saving the muscle definition.

Clinical case 4.4.12. (Figure 4.108-4.112). Though we create conditions for full-thickness graft survivals on the granulating wound it usually adapts up to 10-14 days with areas of parabiosis and phlycten. For better full-thickness autograft survival and worse growth of the scar tissue our clinic has been using autofibroblasts since 2017.

Figure 4.108. Granulations one month after the burn injury

Figure 4.109. Granulation were excised according to the described in this chapter method

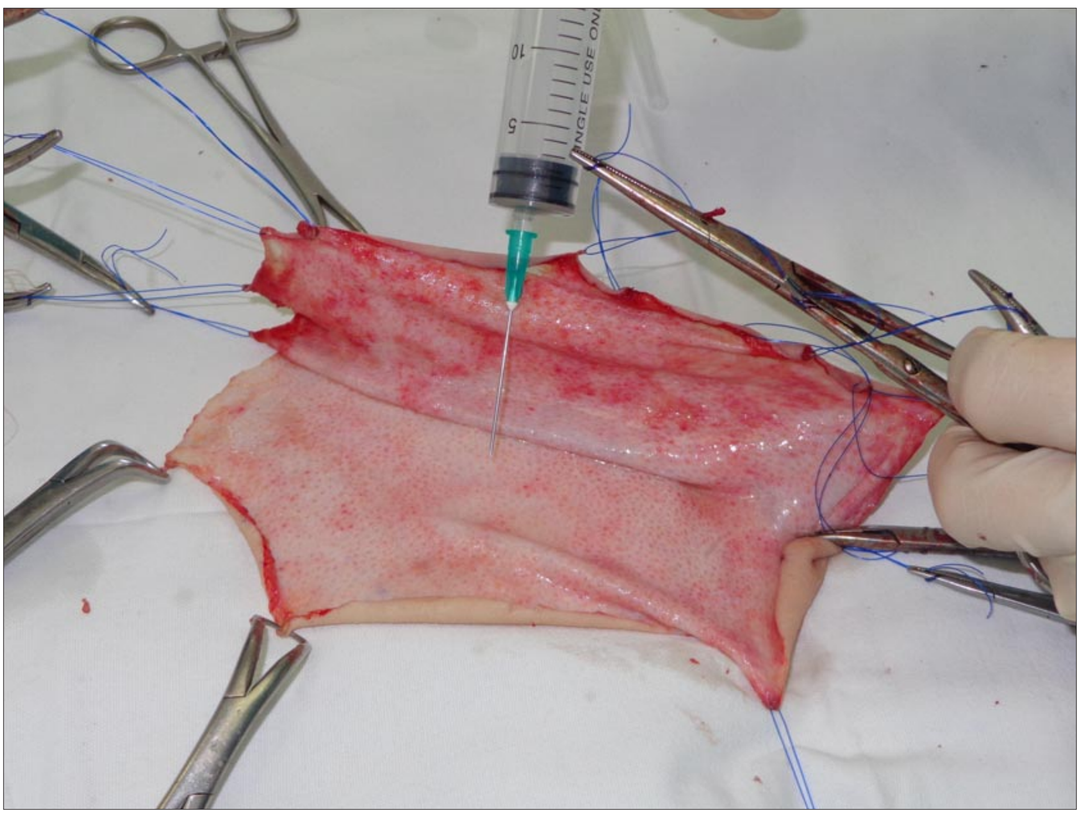


Figure 4.110. The full-thickness autograft and the wound are "poured" with autofibroblasts in the solution for 30 minutes before the plastic surgery

Figure 4.111. The surgery with a full-thickness skin graft is performed

Figure 4.112. Perfectly adapted graft at day 6 post-operatively

4.4. Epithelization of donor wounds

If the area of the burn injury is large a graft can be harvested from any site because our primary objective is to restore the wounded skin. However, in case of deep facial burn you should leave some areas on the donor site for harvesting of wide and long grafts.

The site for harvesting and the harvesting technique are very important when a surgeon deals with deep local burns. We harvest the grafts from less important cosmetic and functional sites. You should consider the patient's postoperative bed position and patient's character. In our observations we initially restored skin integrity in patients with deep burns of extremities and body. We conducted early surgical treatment and staged surgical treatment of facial wounds. From the first days we defined a donor site. Therefore, this skin area was not used for graft harvesting to treat other deep burns.

According to the classical treatment donor sites should be easy to harvest using a disk dermatome with the tangetial excision, and be enough for making a graft with a thickness of 0,2-0,4 mm. In thin patients with the reduced skin tightness for the harvesting in bone structure projection we infiltrated their skin with 0,9% NaCl saline to create pressure and expand their skin.

When we performed the full-thickness skin grafting, the donor site was especially important because we used so called "double closure plasty" to cover the donor site with a thick split-thickness graft (0,2-0,3 cm).

A technique of donor-site reconstruction was as follows:

– A full-thickness skin graft with width up to 10 cm was harvested with a dermatome up to the lower layers of dermis and mosaic areas in the subcutaneous tissue. Simultaneously we performed the split-thickness skin autografting with perforation (Figures 4.40-4.41). Figure 4.113 demonstrates the result of the donor site treatment.

Figure 4.113. Donor site a year after plasty with “double closure”

– When we harvested an autograft with a scalpel manually and saving the dermis (Figure 4.114), we made the primary plasty on the left dermis. Early and long-term results of donor site treatment are presented on s Figure 4.115-4.116. Autograft harvest in the treatment of major defects is as follows. For the treatment of major skin defects in functional zones (face, wrists) the full-thickness skin autografting is usually indicated. The surgical site is prepared according to the accepted standards. The skin defect is measured. Then we mark a supposed donor site on the healthy skin. Using a scalpel we make a bordering incision of necessary size. An autologous skin graft is held and excised up to the subcutaneous tissue saving mosaics in the lower layers of the dermis (Figure 4.114).

Internally the graft is procured using a dermatome and excising 0,1 mm of dermis . Width of a full-thickness skin graft is 1-2 mm and depends on the thickness of dermis on different donor sites. Free split-thickness skin autografts are harvested with a powered dermatome from free skin areas with thickness 0,2-0,25 mm and 1:2 perforation coefficient, and placed on the donor site of a full-thickness skin autograft (Figure 4.115).

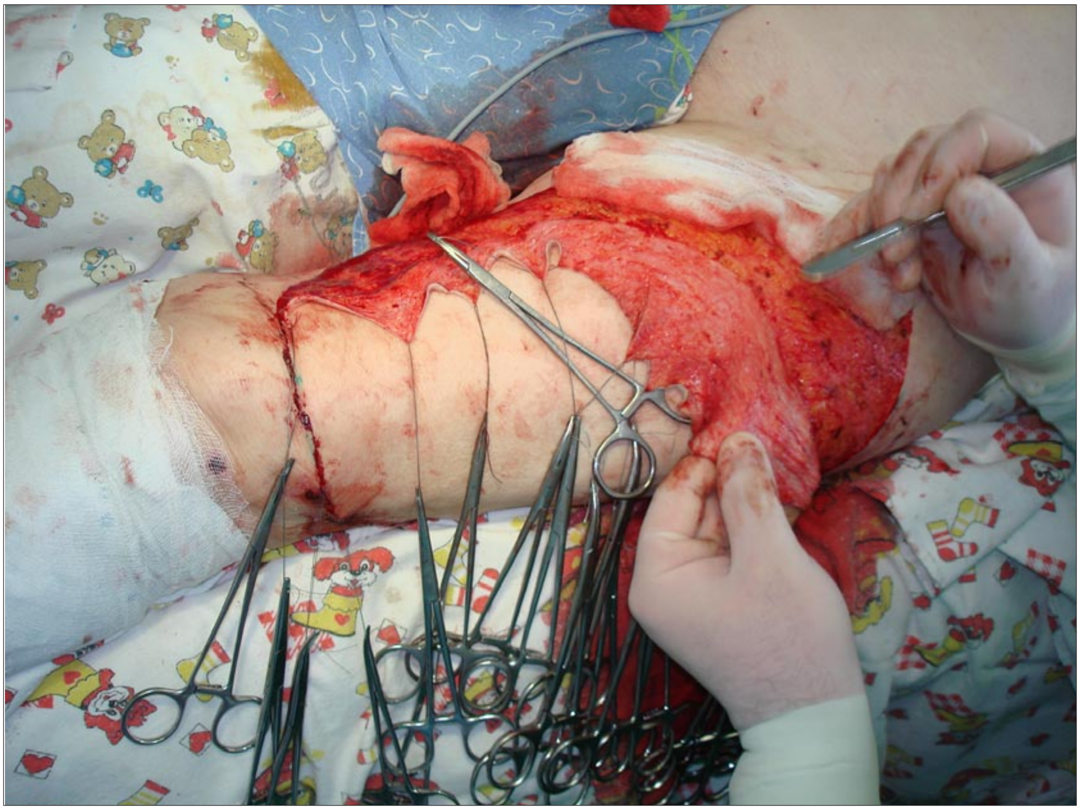


Figure 4.114. Harvesting of the graft, dermis is preserved on the donor

Figure 4.115. Autoplastic of the donor site using 0,2 mm thickness graft

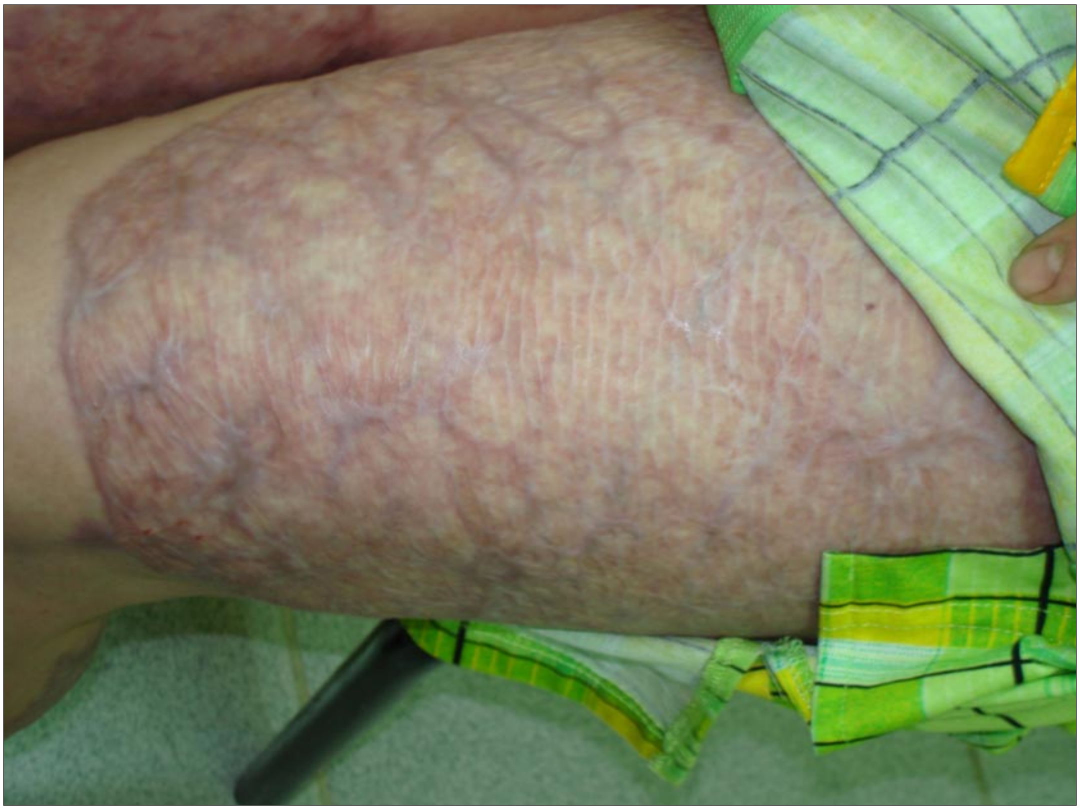


Figure 4.116. Donor site in 3 months

4.4. Epithelization of donor wounds

— If a full-thickness skin autograft was harvested up to the subcutaneous tissue we performed a delayed plasty 8-12 days postoperatively with the granulation tissue formation.

— The vacuum therapy allows creating optimal conditions for the growth of the granulation tissue and performing a delayed plasty on the donor site. It was also used for a surgery with a split-thickness skin graft (Figures 4.117-4.120). We used classical approach to put a vacuum dressing:- no sponge on healthy skin: - to stimulate the growth of granulations we used different vacuum regimes – from 75 till 120; - the first dressing was changed in 2-4 days; - we recommend to put the net gauze bandage between a sponge and a wound. 5-10 days (Figure 4.118) postoperatively free skin split-thickness autografts are harvested from free skin areas using an elecrodermatome with a thickness of 0,2-0,3 mm and they are perforated 1:2, provided there are granulations on the donor site. After harvesting of a full-thickness graft on the donor site the granulating wound is covered (Figure 4.119). Usually the engraftment of split-thickness skin autografts can be observed 3-5 postoperatively (Figure 4.120).

Figure 4.117. Vacuum therapy for the granulation growth

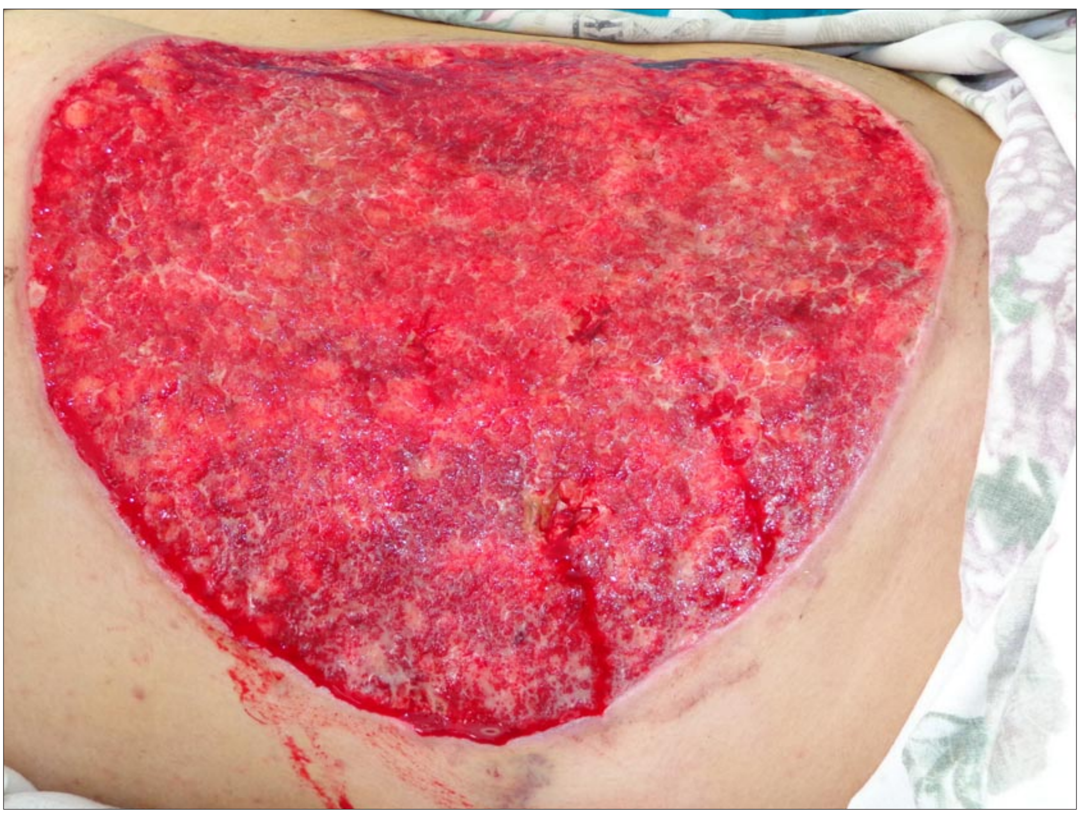


Figure 4.118. Granulation tissue is formed in 8 days

Figure 4.119. Autografting with perforation 1:2

Figure 4.120. Donor wound in 20 day after skin harvesting

Figure 4.121. Patient and his surgeon before the discharge. The new long-waited face after 19 years of anchoritism. The full-thickness skin graft was harvested from the right half of the abdomen and the split-thickness graft from the left one

4.5. Practical recommendations

In the previous chapter we demonstrated clinical cases with treatment stages and described necessary conditions for the survival of a full-thickness skin autograft in patients with deep facial injuries. However, we would like to sum up and underline important aspects of this method.

1. In case of deep facial burns for the survival of a full-thickness skin graft on a granulation wound you should excise granulations up to the lower fibrous layer. So you will excise the infection which prevents graft survival. Granulations, the predecessors of the scar tissue, are also excised.

2. It is advisable to excise wounds bordering granulation tissue and also areas which epithelize more than 15-17 days, and then perform a plastic surgery with one autograft. This procedure helps to prevent scarring of the edges and areas forming the scar tissue. It is recommended to excise everything and then treat the scar.

3. Granulations should be excised using a scalpel with the limited coagulation because it causes micro necrosis (burns) and prevents a full-thickness graft survival. Excision takes more than 2 hours. To excise 1 square cm you should immediately press the excised area with the diluted warm adrenaline solution and coagulate punctually only great vessels.

4. Full-thickness autograft can be harvested from any healthy area, however, because the surgery takes a lot of time the second surgical team should harvest the graft and place the patient in the supine position, - from free skin areas anteriorly. You should remember about hair-covering of the donor site that will be transplanted to the face. It is also not desirable to harvest grafts from the anterior surface of the abdomen in parous women, because they have scars after stretch marks that are not visible from epidermis site. They will be visible during full-thickness graft expansion. Therefore, in girls the anterior surface of the abdomen should not be used for harvesting, if it is possible.

5. To reduce the surgical time, provide better survival of a split-thickness skin graft on the donor site and minimize traumatic effects the delayed plasty of the donor site should be performed.

6. To improve the preparation of a full-thickness skin graft it can be harvested with the fat tissue which should be further excised with scissors. A disk dermatome smoothes dermis from the inside making tangential excision. And excise 0,2 mm dermis from the inside. The graft is stretched on the soft elastic surface imitating the anterior surface of the thigh. This technique allows saving surgical time, preventing graft perforation during harvesting and smooth dermis from the inside.

7. Our experience has shown that patients with deep facial burns do not put attention to the additional donor site necessary for the harvesting of split-thickness graft to close the donor site from full-thickness graft. The donor site that is used for patient’s face should have appropriate colour and elasticity. “The best skin is for patient’s face”

8. Full-thickness skin grafting requires suturing of graft edges to the healthy skin according to the standards of plastic surgery: dermis to dermis, epidermis to epidermis.

9. For the graft survival surgeons should provide uniformly disturbed pressure using rollers, bandages, balls which create a relief of a person's face. The vacuum therapy can also be used.

10. A full-thickness skin transplant heals slowly. Phlyctens, cyanosis, micro bleedings and the subsequent reabsorbing are possible.

11. The surgical treatment should be performed in a stable condition, when anabolism prevails over catabolism. For full-thickness graft survival the patient’s skin should have excellent tissue regeneration.

12. The described method should be used in large specialized burn centers with sufficient well-trained staff of combustiologists and ICU team.

CHAPTER 5.
TYPES OF SURGICAL TREATMENT IN COMBUSTILOGY

5.1. Organization of medical care for patients with burns

In the modern world, according to a number of authors, burns are the third-sixth most common injury. Officially, burns are the sixth (2,4%) most common injury, about 2.1 cases per 1000 adults. Children comprise 30-50% of all affected with burns, both in Russia and in the world. According to the organization "Society of combustiologists "World without burns", 420-450 thousand of burn victims seek health care annually. Burns are not only medical but also social and economic problems.

At present combustiology remains one of the few medical specializations in Russia with adopted regulations for providing medical care (www.combustiolog.ru). So, we have to keep up to date, improve and analyze medical care for burned patients.

In large cities patients with burns are immediately admitted to burn departments and centers for specialized medical care. In small districts of Krasnodar region as well as in other Russian districts the majority of patients are admitted to residential health care facilities. However burn victims, especially patients with burns on functionally and cosmetically important areas, should be hospitalized to a special burn bed for effective medical treatment in the early days.

There were 78 specialized burn departments and centers in Russia in 2010-2014, and since 2015 this number increased to 80.

The increase in burn victims, absence of burn units in a number of regions, need of early referral to specialized burn beds require organizational assistance in the light of Russian territory. According to 25-year of Health Order No 54 dated April 3, 1991 "On measures for further development and improvement of medical aid to victims of burns in the RSFSR", the number of burn beds available per 10, 000 people shall be 0,4, and these figures are only 22,5% of the required amount.

Forty five specialized burn beds were organized by 2016 while the normal number of beds is 206. Specialized beds were organized only at Krasnodar Regional Clinic Hospital No.1. Thus, the number of beds is 0.09 for 10, 000 population.

Given the age structure, 42 specialized children and 168 adult beds are required. Since 2009, there have been 45 burn beds (20 children and 25 adults) in the Region. There is a decrease in the number of beds over time: there were 107 specialized beds in 2005.

Reduced number of burn beds is associated with some legislative acts, one of which is the order of the Ministry of Health to organize combustiologic beds in regional and territorial centers. Thus, in the major cities of Krasnodar region, such as Sochi, Novorossiysk, Armavir, Yeisk specialized burn beds have been reduced since 2005. The most pressing issue was the earlier transfer of patients to specialized beds.

Burn Department was registered as Burn Center on the functional basis of Krasnodar Regional Clinic Hospital according to the Order No 2039 "On the improvement of care for children and adult population of Krasnodar Region with burn trauma" issued on August 14, 2009. The Center also includes ICU providing anesthesiological and resuscitation care for burned patients. And there is a room of rehabilitation surgeon, who is a staff member of the Burn Unit. Out-of-hospital care and follow-up services were provided here to patients with burn and their consequences.

In Krasnodar Burn Department and then in the Center, early surgical treatment has been adopted since 1995. In 2015, 87% of burn victims were treated by this method. The exception was patients with late arrival in hospital and victims with severe "age" comorbidity.

Since 2009, the Center has actively begun using wound dressings for all victims. Early necrectomy and dermabrasion with wound dressings followed by self-epithelialization of burn wounds were adopted.

Over the past decades, there have been a number of trends in burn injuries and health care levels in Russia, which requires analysis of aid effectiveness to burn victims. In adults, there is a general decrease in the number of burns, but the trauma is more severe. In the children, there is marked increase in the percentage of burns in the younger age group.

On August 14, 2009 the Order No. 2039 "On the improvement of care for children and adult population of Krasnodar Region with burn trauma" was issued by the Department of Krasnodar Region in order to provide early treatment of all victims of Krasnodar Region, early transfer to specialized beds, improvement of the functional and cosmetic results of treatment in the Region. One of the main guides of the order are: the establishment of the consultation office in the Burn Center; hospitalization in trauma and surgical wards within 3 days after the injury to clean surgical beds; registration of intensive care burn patients in the Burn Center; registration of burn patients from hospitals of the Krasnodar Region with the presence of burns, requiring early surgical treatment; early surgical treatment only in the Burn Center; autoplasty in children in the Burn Center; autoplasty in adults (area of up to 3%) in the localities only after consultation with the Burn Center.

According to the Order No. 2039 "On the improvement of care for children and adult population of Krasnodar Region with burn trauma" issued on August 14, 2009, all patients diagnosed with burns are registered within the first hours after the injury in the Consultative Department (Division of the Burn Center):

— 3a—3b—4 degree burns in children of any size regardless of the localization;

— 1—2—3a degree burns in children affecting area from 3%;

— 2—3a degree burns in children of a burn size in functionally and esthetically important areas (face, neck, hands, feet, major vessels, genital organs);

— 3b—4 degree burns in adults of any size regardless of localization;

— 3a—3b—4 degree burns in adults despite of a burn size in functionally and esthetically important areas (face, neck, hands, feet, major vessels, genital organs);

— limited 4 degree burns - pathological process extends to bones structures, tendons with joints and major vessels.

— 1—2—3a degree burns affecting more than 10% of the body.

It was very important to organize the medical care for patients with thermal injuries affecting more than 30% of the body surface and having thermoinhalation trauma. Such patients were registered in the Burn Center, according to the above-mentioned order No 2039 issued by Regional Medical Department on August 14, 2009, within the first days after the burn injury. After anti-shock measures provided following a consultation with the Burn Center, patients were transferred from treatment and preventive care establishments (TPCE) of their region to the Burn Center by reanimation teams. In our opinion, if you have the adequate transport support with reanimation teams such as medevac helicopters or class C reanimobiles, do not wait for rescue from the burn shock by TPCE forces.

Due to the support of the administration of Krasnodar region, our Center has a helicopter deck for helicopters up to 3 thousand tons with ICU hall and three elevator shafts on the roof of the Krasnodar Regional Hospital. Annually, 350 patients, including 30 patients with severe thermal trauma, are urgently transferred by our reanimation teams. Given the geographical location of Krasnodar (in the center of the region – maximum distance 270 km), it takes 40 minutes to transfer patients by the sanitary aviation. To provide technologically advanced care for patient with a number of nosologies such as arterial bleeding, myocardial infraction, stroke, compliance with the rule of "golden hour" is very important. Evacuation of burned patients from regional in-patient facilities should be maintained within three days after injury. The "air reanimobile "has the widespread geography: landings on mountain areas, sea and steppe regions of Kuban. Thanks to sanitary aviation, the delivery of patients became faster, safe and more comfortable. Compare: it takes 8 hours to transfer the patient by a car from Sochi to Krasnodar, and 40 minutes by a helicopter.

The region provides care in 44 districts. Necrotomies, necrectomies and autoplastic surgeries are performed on granulating wounds only among adult patients.

Surgical treatment of patients with local borderline and deep burns in functional zones is a serious medical and social problem.

In regional TPCE adults with burn area less than 3% undergo autoplastic surgery only after the consultation with the Burn Center by calling sanitary aviation and following a preliminary photo report via WhatsApp or Viber.

Since 2009, the Center has actively begun using modern wound dressings accompanied by early surgical treatment of 2-3 degree borderline burns. Such injures result in a 2-3 degree borderline eschar, under which independent epithelization may develop within three or more weeks, followed by scar regeneration of epithelized areas causing contractures. To improve quality of treatment, reduce treatment duration, enhance its effectiveness, reach positive functional and cosmetic outcomes, our clinic performs early tangential necrectomy using rotor powered dermatome Du-40, Du-60 with primary $4{,}12 \pm 2{,}00$ days after the injury in combination with dermabrasion using Folkman's spoon and brush of "abrasive paper" type with placement of a synthetic covering.

The developed system of early registration and transfer of patients with burns from surgical and trauma regional beds in Krasnodar region to the regional burn center improves the availability and quality of specialized medical care for burn victims, especially children.

5.2. Classification of injuries according to burn thickness

To date, more than 30 classifications of burn injuries according to the depth of injury are known. The degree of a burn varies in different classifications from two till six. Every country has its own gradations of burn thickness.

Nowadays, leading Russian burn centers has adopted the international classification of diseases (ICD - 10). According to this classification, there are three degrees of burns depending on the depth. A number of authors point to detailed but not very clear localization of burn and cold injuries, however, classification according to the depth of injury is clear.

However, during this "transition period" Vishnevsky's classification proposed at XXVII Congress of USSR surgeons is used in Russia (Moscow, May 23-28, 1960): 1st degree burns – skin erythema; 2nd degree burns – vesication; 3a degree burns – non-full-thickness skin necrosis; 3b – full-thickness skin necrosis; 4th degree burns – necrosis of deep tissues (Vishnevsky and coauthors ,1962). This classification is used in some regions of Russia by law and insurance companies.

In Donbas and Ukrain E.Ya.Fistal's classification is used since 1998. It is similar to European classification and has 4 degrees. 1st degree – epidermal burn (1-2 degrees according to A.A. Vishnevsky); 2nd degree burns – superficial dermal burn (3a); 3d degree – deep dermal burn (3b); 4st degree – subfascial burn (4th degree according to A.A. Vishnevsky).

Two- stages classifications are historically known, where burns are divided into superficial and deep (full-thickness) burns. This classification was proposed as international one. According to another two-stage classification, burns are divided into "scar-forming" and "non-scar forming".

3-stage classification is used in the US and West Europe now: 1st degree- superficial burns; 2nd degree – partially deep burns; 3d degree – deep (full-thickness) dermal burns.

The review of these classifications is relevant due to surgical tactics and long-term follow-up. A. Vishnevsky classification adopted in USSR is based on staged local surgical treatment, when 3a degree burns are epithelized independently. Recently, early surgical treatment is widely used in Russia and based on early removal of necrotic tissue. Therefore, eschar-formining burns, 3d and 4th degree and also 3a degree eschar-forming burns should be excised. And practice reveals that Russia gradually transfers to the international classification based on burn thickness.

The changes of classification taking place are caused by the study and analysis of treatment strategy of borderline 3a and 3b burns. 3a burns usually heal during three weeks after the injury. However, it is known that unassisted burn healing longer than 18 days considerably increases the risk of post-burn scar deformities and contractures due to insufficiency of growth elements for adequate regeneration. The classification used in Russia does not divide burns into superficial and deep dermal burns – they are both 3a degree burns, though they are considerably differ in treatment duration and healing results.

New devices and methods are being developed allowing evaluating the depth of injury before necrosis excision, however, at present, the clinical method of the depth measuring dominates in practical combustiology.

5.3. Staged surgical treatment

Deep injuries cause skin necrosis (eschar), which is gradually rejected by the body. These processes occur in the wound as follows: eschar formation, inflammation and suppuration, staged rejection (sequestration), wound cleansing and formation of the granulation tissue ready to plastic surgery. These processes take from 1 till 2 months and require intensive both general and local treatment; and the patient is treated surgically step by step.

Wound process in combustiology does not significantly differ from the classical wound process that initially was divided into different periods by A. Charukovsky in 1836. He distinguished four periods: bleeding, inflammation, suppuration and healing. In 1856, N. Pirogov identified 3 stages in wound process: edema, wound healing and formation of granulations. The first foreign author who described different phases of regeneration was J.Marchand in 1901. He divided this process into three stages: inflammatory, proliferative, reorganization and scar remodulation. Well-known periods also occur in the wound during the injury; however, they essentially differ depending on the depth of the injury.

Burn wounds are especially severe injuries because they cause intoxication and exhaustion. Thus, the earliest preparation of wounds for covering using staged surgical treatment is one of the most important challenges. Treatment of children due to specify of their organism, such as hydrophilicity and thinner skin, requires special surgical strategy.

Staged surgical treatment in patients results in a wide range of activities requiring intensive infusive therapy and anti-bacterial treatment. In adult patients, intensive treatment is generally provided in case of large burns, however, in child combustiology, due to more severe wound process, intensive treatment is indicated for smaller injuries.

Technically, staged necrectomies accompanying surgical treatment are performed as often as eschar sequestration requires. This method of treatment, used in the 20th century, is performed without bleeding and wound cleansing from necrotic eschar. Less intrusive necrectomy is generally performed under anesthesia. Scissors or scalpel gradually excise rejected necrotic tissues. Areas with sequestration should be removed. Necrectomy starts usually at the end of the second and the beginning of the third week after the trauma.

Dressings are changed until wound epithelization and autoplasty during one month. Hydrotherapy, hyperbaric oxigination, physiotherapy are indicated. These methods allow boosting the growth of granulations and preparation for autoplsaty. The wound surface is not usually prepared to the autoplasty at once. If hyper-granulations develop at a later period and also for excision of inflammatory-induced leukocyte migration, tangential excision of the granulation wound (so called “TIGER”) is indicated. This technical method involves significant blood loss and hematomas that may form under the autotransplant.

Figure 5.1. Results of two weeks self-treatment using traditional medicine. The burn is complicated by sepsis and polyorganic insufficiency.

Figure 5.2. Necrotic tissues with festering subcutaneous tissue are excised. Intensive general and local treatment.

Figure 5.3. Amputation of the foot along the zone of demarcation of dry necrosis.

Figure 5.4. In a week the wound is cleaned from fibrin.

Figure 5.5. In 10 days granulation tissue is developed, harvesting of autografts from the right tibia is planned.

Figure 5.6. Skin autoplasty using perforated grafts with thickness of 0,2 mm is performed.

Figure 5.7. Skin is restored in 2 weeks after autoplasty.

Figure 5.8. 7 days after the fire burn. Deep necrosis is developed.

Figure 5.9. We put 20% salicylic acid ointment and dry dressings to accelerate staged necrectomy.

Figure 5.10. 3 days after chemical necrolysis, eschar is sequestrated along the demarcation zone.

Figure 5.11. Granulation tissue is developed along the sequestration zone in 7 days after the chemical necrectomy.

Figure 5.12. Tangential excision of granulation tissue is performed under tourniquet on the middle third of the thigh.

Figure 5.13. Autografting using a split-thickness skin graft with a thickness of 0,3 mm without removal of torniquete.

Figure 5.14. Positive result of plasty with cellular epithelization.

Figure 5.15. If granulations or hypergranulations develop, leukocyte migration in granulation tissue should be excised before plasty.

Figure 5.16. Hydro-surgical system "Versadget" is used since the 21th century, which allows equal excision of granulations, with hemostasis.

Figure 5.17. Autoplasty with perforation is performed in 3 weeks after the trauma, following the development of granulations and their processing with “Versadget”.

Figure 5.18. Good adaptation and cellular epithelization are observed in 7 days.

Figure 5.19. Full engraftment due to excision of granulations using “Versadget”.

Figure 5.20. 2 days after the surgery, before discharge; complete epithelialization.

Figure 5.21. Staged management of the contact burn of the hairy part of the head

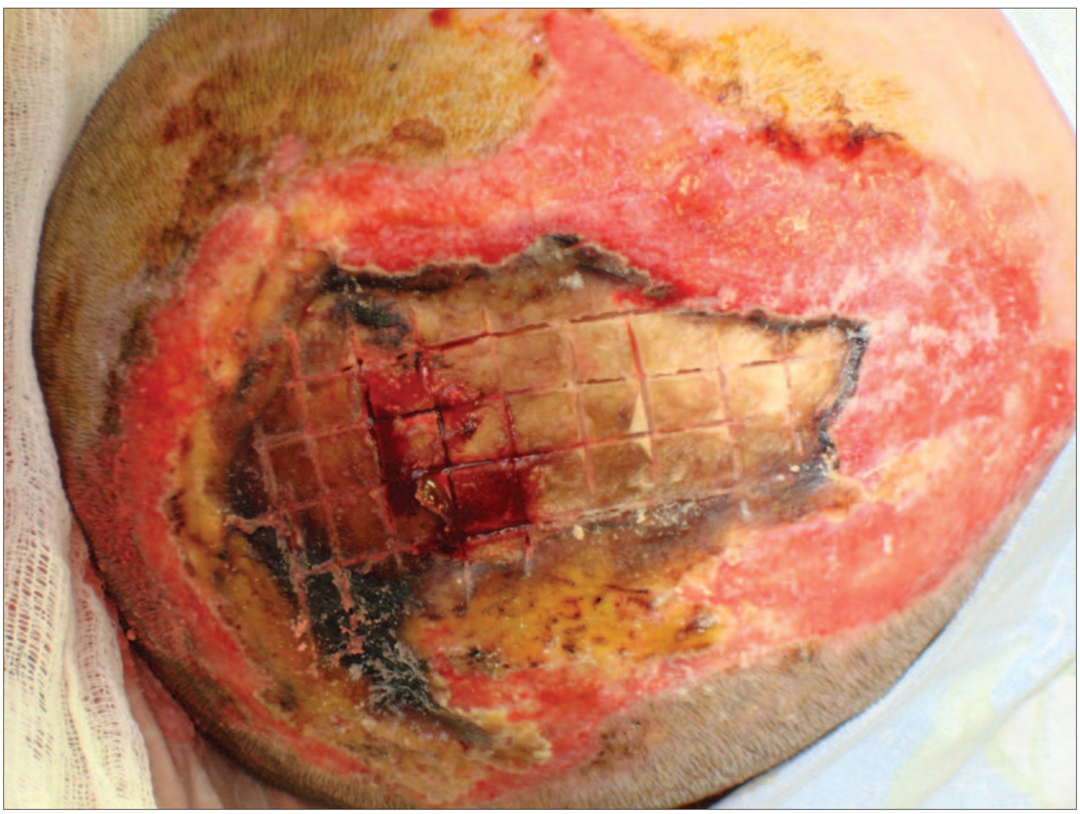


Figure 5.22. Skull cutting of osteonecrosis reaching the bleeding layer.

Figure 5.23. Osteonecrectomy reaching bleeding layer of the skull is performed.

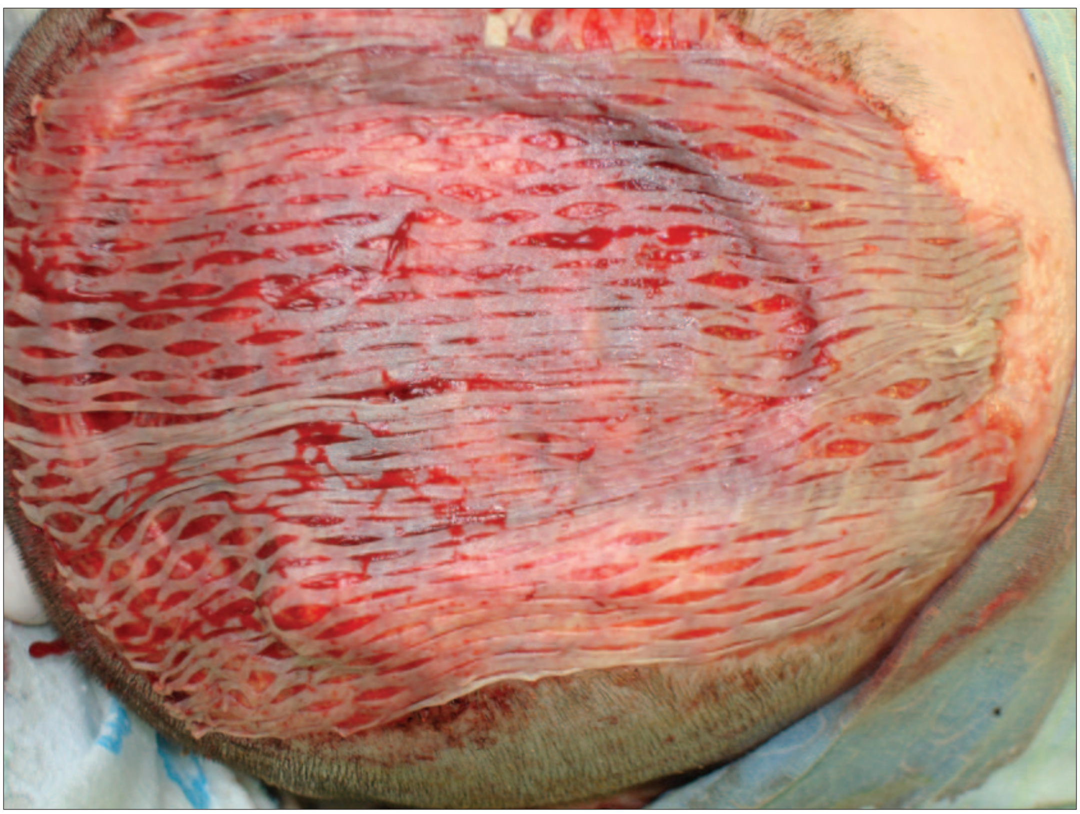


Figure 5.24. Autoplasty with perforation 1:2 without stretching is performed.

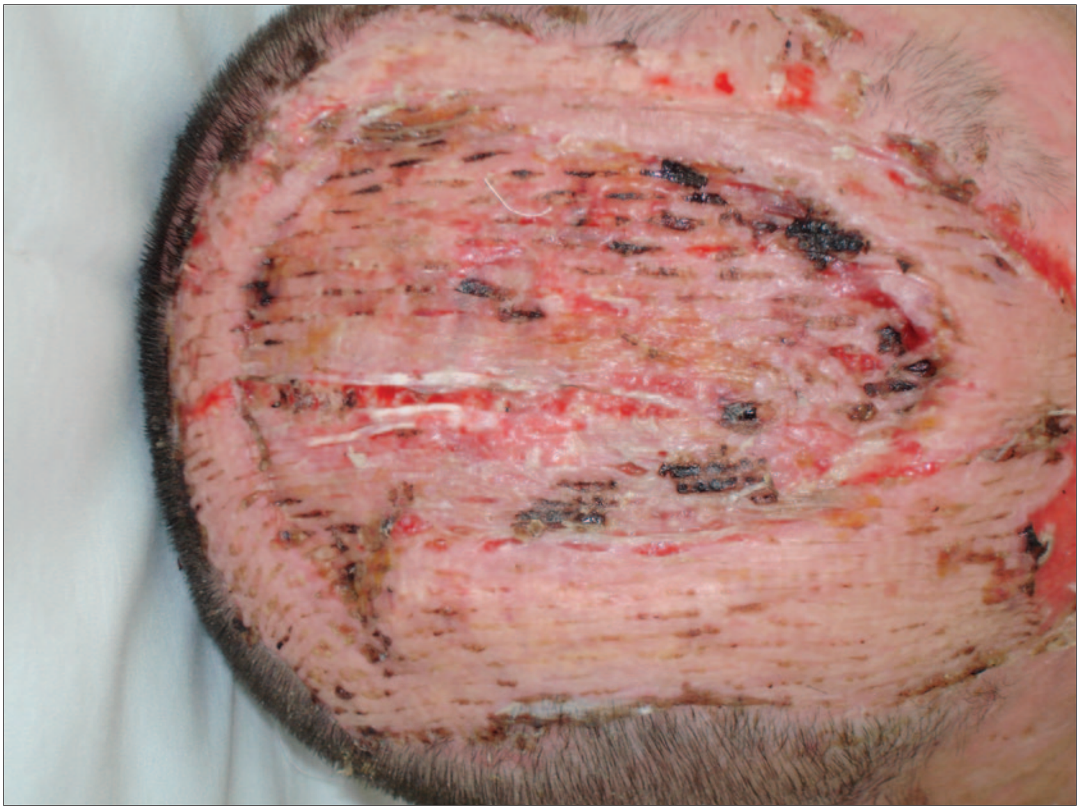


Figure 5.25. Surgical outcomes before discharge on 10 postoperative day.

5.4. Early surgical treatment

Methods of early surgical treatment are being improved to reduce a treatment time. The first attempt of deep burn excision and suturing was made by Redriger in 1888. The first attempts of surgical debridement of burns using a dermatome were made by Wells in 1929, Young in 1942 and Core in 1947 (MacMillan B.G., 1981). In addition to excision of necrosis some authors perform primary autoplasty using free skin autografting in an early period (Ariev T.Ya., 1971). However, transplants engraft in aseptic conditions, unlike stage surgical management. It is optimal and gives better functional results. Early skin restoration using primary tangential excision with simultaneous skin autoplasty for deep dermal and some subdermal burns may decrease frequency of hypertrophic and keloid scars. Generally, surgical treatment of deep burns is limited to two main types of surgeries. The first one is the removal of dead tissue (necrectomy), the second one is the restoration of lost skin. Dead tissues (eschar) are the main reasons of intoxication and microbic inflammation often disrupt the adaptation. Only early removal of eschar allows completely avoiding these undesirable outcomes. Early necrectomy after injuries has two main goals: removal of eschar, which is one of the main reasons of infectious and toxic complications, and acceleration of wound preparation for plastic closure.

Necroses are excised both by a scalpel and powered tangential dermatome. It allows excising large necrotic areas, regulating the thickness of a slice and creating smooth surface ready for autoplasty. During 50 years, early free skin autoplasty remains the most progressive method of surgical treatment of deep burns, that considerably reduces time of treatment and gives better functional outcomes, as compared with skin transplantation on granulations. Early excision of necrotic tissues is especially promising for burned major joints, hands, feet because it allows saving their optimal function. Even insignificant scar formations in these areas can lead to severe flexion contractures requiring further reconstructive surgeries.

Early necrectomy is the method of choice. Up to 10-15% of body surface is usually excised during one surgery. This method was applied in treatment of limited burns at the earliest. The adequate anesthetic management and intensive care are essential to put this method into practice, both among adult patients and children.

Early necrectomy is accompanied by blood loss. This fact is a major cause of limited possibilities for early treatment. Usually, a square centimeter of the wounded surface loses from1to 3 ml of blood during such treatment. Technical methods to reduce blood loss during early necrectomy are always improved. The rate of blood loss depends on a number of factors: way of excision of necrotic tissues; speed of blood clotting; used hemostatic agents and methods of hemostasis; age etc. Surgeons usually focus on the surgical technique to reduce blood loss, preferring operating under a tourniquet. Major vessels are coagulated and sutured; thrombin solution is used for local anesthesia. Surgeries of extremities are performed using tourniquets, than a wound dressing is placed, a tourniquet is removed and, following hemostasis, autoplasty is performed.

The known methods to reduce blood loss are hemodelution, diathermocoagulation, physical factors (cold, heat, laser radiation etc). Intra-operative blood loss may be reduced by preliminary infiltration of tissues under excising eschar using adrenaline solution or 30% ethanol two days before surgery that causes aseptic inflammation and vascular thrombosis of fat tissue. The historical fact is that tangential excision of dead tissue usually leads to more intensive blood loss then removal at the level of fascia, so the surgery is more traumatic.

Blood products and their substitutes are widely used in treatment of burn injuries for general treatment and surgical treatment with compensation of the lost blood. There is also evidence that blood transfusion in previously burned patients increases immune defensive forces in recipients. Blood transfusion is very often and sometimes every day practice during wound preparation for skin plasty on granulations, especially while preparing wounds to skin plasty on granulations, some works are devoted to autohemotransfusions.

Technical skills of necrosis excision are considered to be important. Three types of necroctomies are distinguished: 1) tangential; 2) sequential; 3) excision till fascia or deep tissues. Yu.I. Turnikov and coauthors also proposed the detailed classification of “active surgical preparation of deep burns to the plastic closing”. According to this classification, primary surgical necrectomy is performed up to 5 days after the burn. It is interesting how authors divide necroctomy according to the depth of excision: 1) dermal – reaches residual derma (3a-3b degree “boderline” burns); 2) fascial – reaches visually viable fascia, leaving it; 3) fascial and muscular; 4) osteonecrectomies.

The excision was called tangential (full-thickness) by Janzekovic in 1968. Most progress on surgical treatment of deep burns has been made in 1968 when Janzekovic described the technique of tangential excision of eschar, and in 1975, Burke published the article describing simultaneous excision and autodermoplasty of burn injuries in 11 children using immunosuppressive drugs and allotransplantation. While tangential excising, if the wound bed consisted of residual dermis and/or narrow-meshed subcutaneous tissue, the primary autoplasty was performed, and it usually gave positive survival outcomes. Primary plasty on coarse-grained subcutaneous tissue gave unsatisfactory engraftment outcomes due to its bad blood supply. Some authors call fascial necrectomy "skin amputation". Fascial necrectomy gives unsatisfactory cosmetic and functional results.

Early necrectomy improves general condition due to necrosis removal, which is a substrate of intoxication and sepsis. Early surgical treatment also speeds up the healing process and demonstrates better functional and cosmetic long-term outcomes due to reduced formation of scar tissue, in contrast to staged surgical treatment. Shorter period of treatment reduces need in antibacterial therapy. Time of early surgical treatment should be discussed. In case of limited burns, all authors advise early removal of necrosis, at day 1-2 after the injury. In case of large burn injuries and severe condition, surgical treatment with relative stabilization of the burn prevails, at day 2-4 after the injury, especially when primary autoplasty follows early necrectomy. Two days after the injury is the optimal period of surgery of hands, provided a surgeon has measured the injury and does not doubt in its depth. Necrectomy with autodermoplasty within first 80 hours is called the means of early rehabilitation in the vast majority of patients after surgery.

5.4.1. Dermabrasion

New modern dressing materials, which stimulate epithelization and give better outcomes, appear in practical work of Russian combustiologists every year. One of the main factors of successful treatment of patients with burn injury is optimal conditions for epithelization. It is known that epithelization depends on thickness of injury, infiltration rate and phase of the wound process. In combustiology, in contrast to other surgical and trauma specializations, patients have injuries of large areas. Their treatment requires knowledge of practical usage of different dressings.

Modern wound covering in combustiology should have following characteristics: do not stick to the wound; have pain relieving, antibacterial and stimulating properties, create moist environment in the wound. In the last decade, main direction in local treatment of burns is usage of dressings with silver, which make the wound wet. Antibacterial properties of silver suppress wound infection and prevent reinfectioning.

80% of patients, seeking medical care and referred to our in-patient department, demonstrates superficial and borderline burns, and most of them were children.

All patients are objects of surgical treatment. Treatment of superficial burns, affecting epidermis and all layers of derma, is conservative and usually does not very difficult. Usage of modern dressing materials and thorough control of infections in a wound allow healing within two weeks.

More difficulties would arise with borderline burns affecting deep layers of derma. Burn eschar formation and private unsatisfactory outcomes of conservative treatment make this group closer to deep burns in the light of surgical strategy. Moreover, in every case surgeons, who estimate risk and negative consequences of surgery, should decide if surgical treatment is necessary. Usage of modern wound coverings in patients with burns considerably increases efficiency of their treatment by reducing time of wound epithelization. Recently, some studies analyze usage of wound coverings on the soft scar tissue in order to improve neoepithelium within the first days after epithelization.

Close-type modern dressings (occlusive) create optimal conditions for migration of phagocytes carrying out autolytic necrectomy. Such method of removal of injured tissues makes wound cleaning especially selective, not damaging viable areas, which can regenerate. The restoration of skin layers after such treatment gives more positive functional and esthetic results. This approach is especially promising in treatment of esthetically important open parts of the body and, first of all, the face. Recently appeared biosynthetic skin substitutes (Integra, Matriderm) can be alternative to skin transplants. They can be used both in treatment of fresh burns and reconstructive surgeries. One of the most interesting materials is Integra, it is a double layered membrane from biosynthetic material and silicon. Biosynthetic material is the basis for vascular and cellular proliferation, it gradually degrades within two-three weeks, then silicon layer is removed and plasty using a split-thickness skin graft is performed. Nowadays, there are a small number of studies describing biosynthetic substitutes. These studies demonstrate that these materials tend to be infected. There are no impressive advantages of their usage in comparison with skin transplants so far. Nevertheless, their invention is an important step for creation of skin prosthesis.

At present, cell technologies - fibroblast cultures, keratinocytes, ReCell technology, are widely used in treatment of burn injuries. They stimulate healing of large burned areas. However, so far, they cannot be an alternative to facial plasty. Esthetic results do not always meets patients' expectations and such treatment is expensive.

Burned surface always attracted special attention of surgeons; as a result, various drugs for local treatment boosting epithelization appeared. Moreover, there are more such drugs in combustiology than in other medical areas. Only according to official data, there are not less than 3000 drugs for local treatment of burns. Nowadays, more than 600 various drugs are used in practical health care.

Complex approach to the usage of modern dressings for treatment of burn injuries is appropriate.

Biological wound dressings were and are considered to be "the gold standard" as temporally skin substitutes. However, synthetic dressings, creating different conditions for epithelization in wounds of various geneses, are being developed in recent decades. Manufactures add antibiotics, various pharmacological and biological drugs into wound dressings; therefore, their properties become more similar to biological materials.

Depending on the depth of injury and use of various medicines, open or close, "wet" or "dry" methods of local treatment are used for burn treatment. However, various drugs are often used at different stages of the wound process without estimation of their effectiveness.

Drugs for local treatment and wound dressings in combination with physical methods of treatment, such as ultrasound or hydrosurgical burn wound preparation, are developed in order to combat the infection.

In the last decades, the number of wound dressings that, according to their annotation, can be used at different stages of the wound process, is growing. There is a need to systemize usage of wound dressing according to the depth and stage of wound process, create standards of treatment of burn injuries. It is necessary to develop medical technologies: a set of drug and drug-free treatment methods that will optimize diagnostics, rehabilitation and prevention of diseases, and protect human health using knowledge, skills and surgical art implemented in clinical and other practical methods.

Closed method using various dressings is the main way of treatment of superficial and borderline burns. Moreover, in patients with deep burns, surgeons use this method for preparing burn injuries to the surgery and creating conditions for autodermotransplant survival.

Various local stimulators for regeneration of burn injuries are used. Chitozan, natural polymer, obtained from renewable natural resources – chitin of crustaceans' shell (shrimps, crabs etc.), mushrooms or seaweed. Uniformsan has the unique combination of properties: ¬- biocompetitable, -biodegradation - complex former, - immonostimulator, - bacteriostatic and hemostatic effect.

Study and development of new methods of surgical treatment for patients with burns of borderline thickness in functional and cosmetic areas remain relevant.

Figure 5.26. 3 days after 2nd degree burn. result The of “evening tea”. Fibrin, formation of thin eschar.

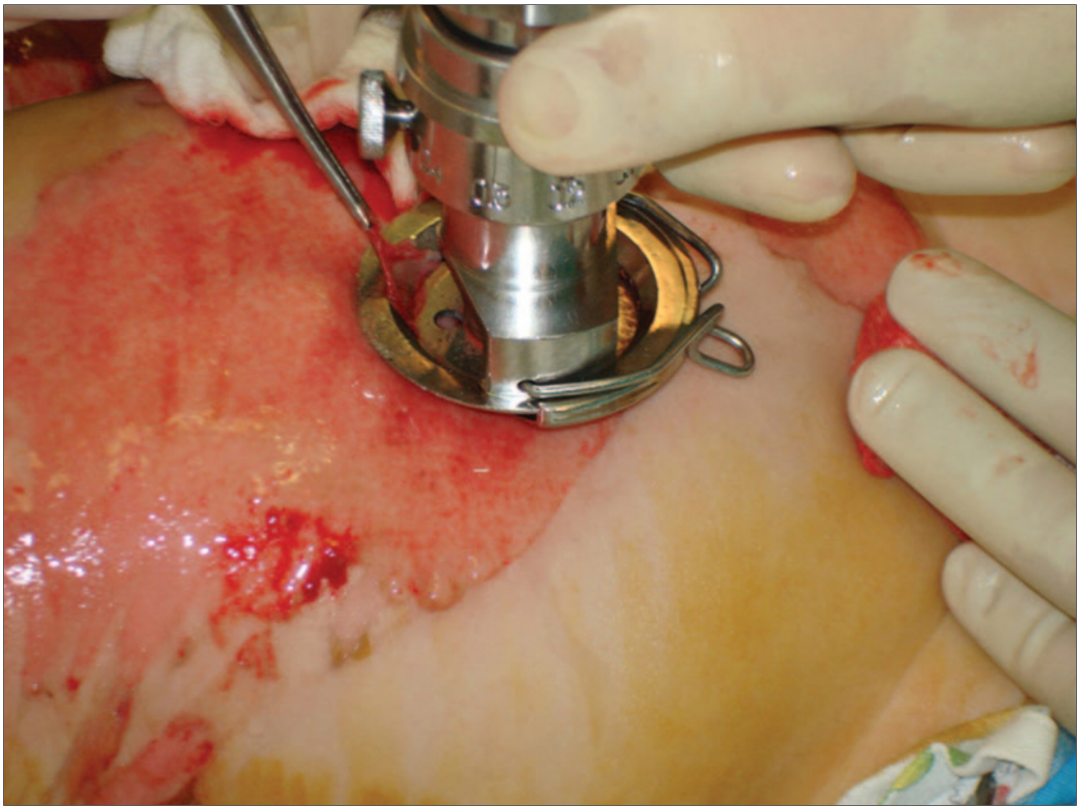


Figure 5.27. Necrectomy and dermabrasion using a necrotome.

Figure 5.28. The wound bed – middle and upper layers of dermis, “clean surgical” wound.

Figure 5.29. Wound dressings with "Hydrofiber" system are applied.

Figure 5.30. The wound is epithelized within 7 days in "clean" surgical conditions, under the wound dressing applied only once.

Figure 5.31. At day 10 after the burn – skin is restored in 1,7-2 times faster in comparison to staged surgical treatment, during one surgery.

Figure 5.32. Superficial scald from boiling water.

Figure 5.33. Mechanical dermabrasion creates moist environment in the wound – wound hydro-dressing is applied

Figure 5.34. Comfortable and painless conditions are created in the wound.

Figure 5.35. The patient did not take off the wound dressing for a week.

Figure 5.36. The wound surface is epithelized in 7 days, at the first dressing change.

To improve dermabrasion and early necrectomy, we developed the method of surgical treatment of borderline burns. Objectives: - improve early autoplasty in combination with dermabrasion for “borderline burn injuries”, 2a-3b degree burns according to Vishnevsky, (2 stage according to ICD - 10) – achieve non-scar zone between autoplasty and healthy skin in postoperative period; -improve functional and cosmetic postoperative results by using a full-thickness free skin autograft on functional zones (backs of hands and feet, joints) and zones tend to scarring (inner thighs, shoulders, forearms).

The essence of this way is that during the first 2-7 days after receiving a boundary burn in the functional zones and zones tend scarring, we perform necrectomy to the lower layers of dermis and autoplasty; and on other boundary sites with burns we remove fibrous and necrotic pellicle within surface dermal layers to the level of a bleeding layer and on the processed burn area we place a wound covering.

Technical results: necrectomy to the lower layers of dermis and autoplasty in the functional zones and zones tend scarring, removal of fibrous and necrotic pellicle within surface dermal layers to the level of a bleeding layer on other boundary sites with burns, and placement of a wound covering for 5-7 days, allows preventing scar development and achieving positive esthetic results during the postoperative period.

Clinical case. Patient G., 30 years old, was referred to our burn department with following diagnosis: 2-3a-3b degree thermal burn (flame) of the face, left upper extremities, involving 11% of her body. Three days after admission, developing necrosis of the left elbow on medial surface and shoulder was observed (figure 5.37). In the OR, under intravenous anesthesia, following the standard preparation of the surgical field using a powered dermatome DE-60, one skin autograft was harvested from anterior-lateral surface of the left thigh with a thickness of 0,2 mm. After the placement of a tourniquet in the upper third of the shoulder, the forming eschar was excised along the medial surface of the left thigh to the lower viable layers of dermis (Figure 1.38). Hemostasis. The wound with good margins formed (figure 1.39). Then necrosis was excised to the anterior surface of the forearm by the powered dermatome, and fibrous-necrotic pellicle within surface dermal layers, on other surface sites of the left extremity up to a bleeding layer was removed by a dermabrasion brush. After that plasty using a full-thickness free skin autograft on the wounded shoulder was performed. Biological wound dressing “UniformPran” was placed on other injured surfaces (figure 140). The surgery took 30 minutes. Antiseptic dressings were used. Good adaptation of autoplasty and staged epithelization were noticed at the first dressing change on postoperative day 4 (figure 5.41). Boundary burns were completely epithelized before discharge on postoperative day 10 (figure 5.42). One- year follow-up demonstrated that due to plasty using a full-thickness skin autograft in functional zone with scar-free zone between operated and non-operated area, scar tissue was not formed (figure 5.43).

Figure 5.37. 3 days after the scald injury, formation of the 2nd degree eschar according to ECD-10.

Figure 5.38. Dermabrasion and tangential necrectomy under tourniquet.

Figure 5.39. Wound bed – lower and middle layers of dermis.

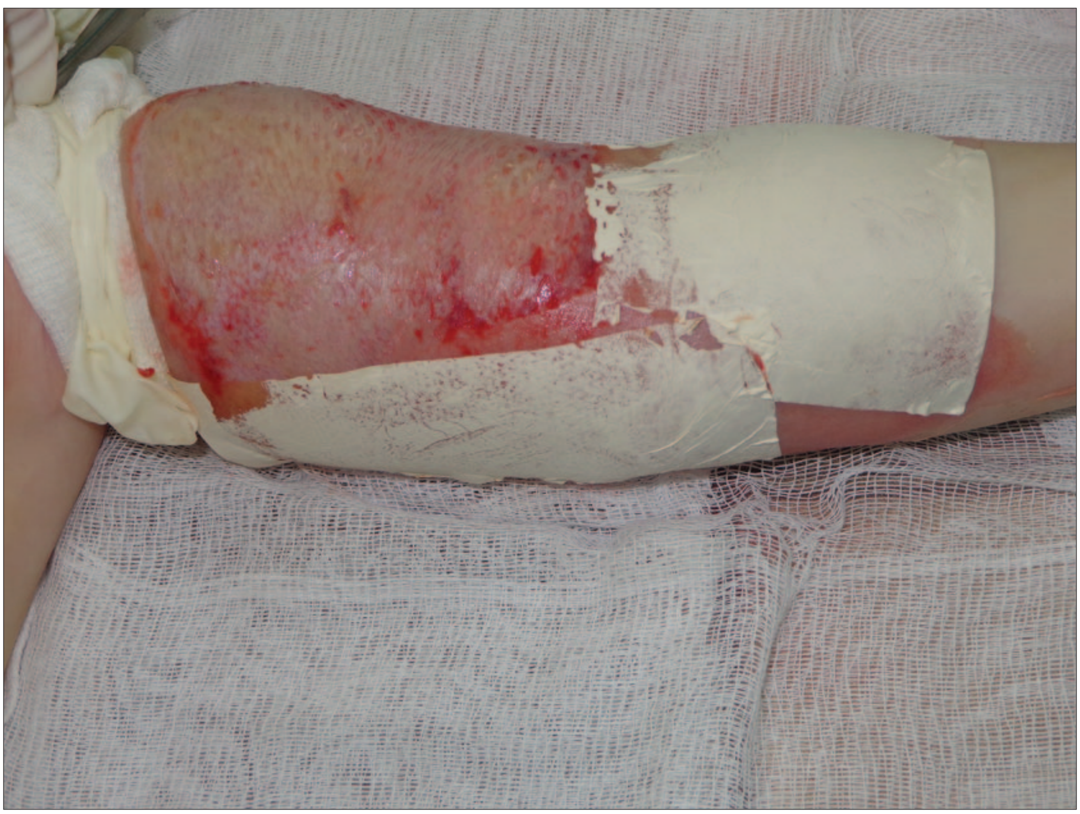


Figure 5.40. Autoplasty is performed under tourniquet and biological wound dressing “UniformPran” is applied.

Figure 5.41. In a week, plasty adopted. Staged epithelization under "UniformPran".

Figure 5.42. Treatment outcomes before discharge, day 10 postoperatively.

Figure 5.43. The burn wound in 3 months.

Figure 5.44. 4 days after the scald.

Figure 5.45. Necrectomy until middle layers of dermis is performed. Hemostasis.

Figure 5.46. Wound healing is applied.

Figure 5.47. Staged epithelization within1 week.

Figure 5.48. Treatment outcomes 7 days postoperatively, 11 days after the burn.

Figure 5.49. 3 days after the 2-3 degree borderline depth burn.

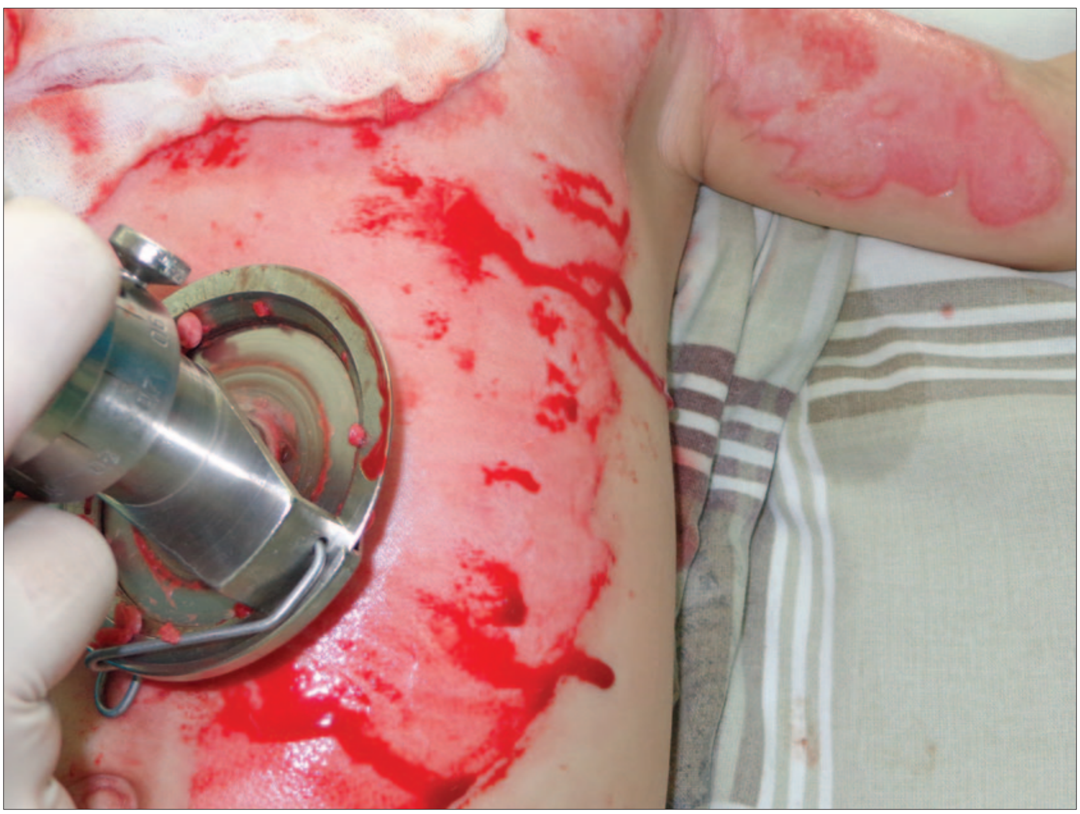


Figure 5.50. Tangential necrectomy is performed.

Figure 5.51. The wound bed – middle and lower layers of dermis.

Figure 5.52. Biological dressing “Supratel” is applied.

Figure 5.53. Epithelization is observed within 5-9 days following the first appliance of the dressing.

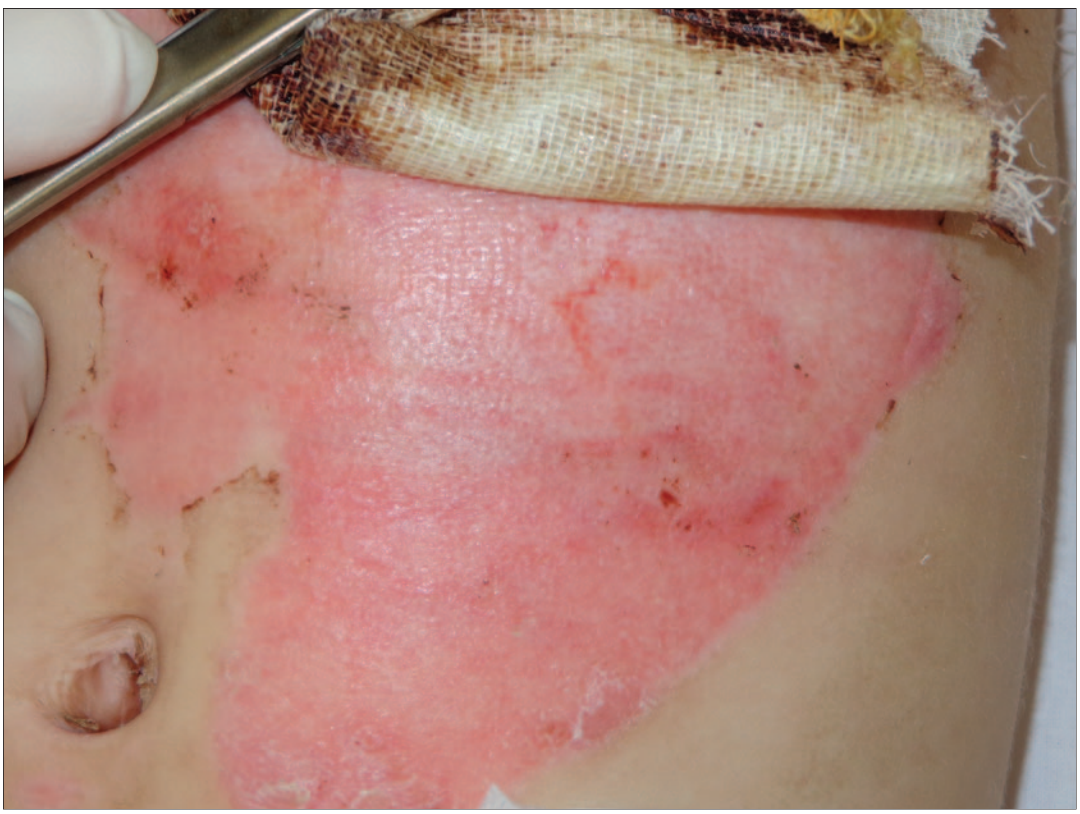


Figure 5.54. In 7 days after the surgery, staged epithelization.

Figure 5.55. Surgical outcomes on postoperative day 10.

Figure 5.56. Scald of the left forearm, 3 days after the trauma.

Figure 5.57. Eschar of the borderline burn is excised.

Figure 5.58. Biological dressing “Supratel” is applied.

Figure 5.59. Meshed wound dressing “VoscoPran with Braunodin” is put on “Supratel”.

Figure 5.60. “Supratel” gradually resolves, the wound epithelizes within 1 week.

Suprathel acts as Active Biological Dressing and Epidermal Substitute

Polymers from polyhydroxy acids – mainly based on polylactic acid (Suprathel) are used in burns treatment for nearly twenty years. There is significant evidence for a variety of clinical benefits such as pain reduction, reduction of workload, short healing time and low complication rates providing excellent cosmetic results in superficial, deep partial thickness and even small full thickness wounds [1–9]. The technology is most suitable for the treatment of burns, STSG donor sites, and burn-like syndromes such as TENS. Based on clinical evidence and literature the positive effects can be explained:

Lactate acts as an energy source for cells:

In a wet environment polylactides degenerate to chemical fragments releasing lactate and lactic acid[10], serving as an energy source for cells [10,11]. Both substances can permeate the cell membranes either due to their molecule size or active transport by the monocarboxylate transporter (MCT) protein shuttle system. Inside the cell, lactate can serve as an energy source via the Cori cycle, or it can oxidize to pyruvate. This again is oxidized to acetyl-CoA fueling the TCA cycle in mitochondria producing the metabolic products carbon dioxide, water, and NADH, which provides the energy-rich NAD [12].

Externally applied lactate shows positive effects:

Intravenously administered lactate has shown to be “a useful carbohydrate source, sparing blood glucose, and liver glycogen in times of increased energy demand”[13]. Lactate elevation by implantation of hydrolyzable polylactide as is the case with Suprathel showed that lactate simulates hypoxic conditions to cells in a non-hypoxic environment, affecting the release of cytokines and TGF ß activation, Hypoxia Inducible Factor, VEGF, and others. [14–20]

Lactate-induced TGF ß has effects on dermal cells[18] and extracellular matrices as well as on keratinocytes[21,22]. It stops differentiation of keratinocytes but increases ECM production from keratinocytes to reconstruct basal membranes and alleviate migration. After wound healing, it is stopped by decorin[23], completing the activation status. [21]

Lactate and pyruvate act as potent antioxidants [10,24–26]within the cells and extracellular matrix, contributing to reduced oxidative stress diminishing organ failure[27] and cellular damage[28].

It can reduce burn wound conversion[2,29,30] and the need for donor areas and transplants to a minimum. By reducing cellular damage, it can help to mitigate radiation injuries[31]. In mixed and partial thickness burns it will heal the superficial and partial thickness areas and even small third-degree burns while it can be used in full thickness burns as a temporary cover for later grafting.

References can be downloaded from:
https://www.researchgate.net/publication/333729127_Suprathel_acts_as_Active_Biological_Dressing_and_Epidermal_Substitute

5.4.2. Early necrectomy with primary or delayed plasty

At limited burns and sufficient skin resources, the skin cover can be recovered in one surgery. When treating patients with severe burns, the problems of donor resource shortage as well as inability to dissect and to close large injury areas in one surgery arise.

Recovery of the skin cover on areas where an eschar was removed by means of surgery is carried out in different ways depending on the chosen tactics of surgical treatment, available donor skin resources and availability of wound dressings. Graft acceptance at primary plasty after necrectomy depends on the overall condition of the body and on the wound state after excision. The unfavorable local factors are the following: exposed subcutaneous tissue and tendons; insufficient hemostasis and formation of blood lakes as a result; insufficient excision of devitalized tissues; late surgery after the burn and inflammation in the wound as a result.

An ideal replacement of the wound defect with skin autografts would be immediately after excision of dead tissues in order to minimize the abnormal effect of the forming wound.

Skin grafts are best accepted during their transplantation on granulation tissue, muscular tissue, fascia, mosaic parts of fine-meshed and subcutaneous tissue and on dermis remaining after excision. Worse acceptance is observed in grafts on fatty tissue, tendons and bone tissue which may be related to insufficient vascularization of the wound bed. Autoplasty of thick (0.3 to 0.5 mm) split grafts due to the fact that such skin grafts are less subject to cicatrization and retraction, gives better cosmetic results in the future. That is the reason why they are used during plasty of functionally active areas, such as face, hands, feet and joint area.

In case of donor site shortage after necrectomy, in order to increase the autograft area the wound surface is covered with mesh autografts of different mesh and elongation index (1:2; 1:3; 1:4; 1:6) which is justified in patients with severe heat injury. Even in case of donor site shortage, graft plasty without meshing is indicated for functional places such as hands and feet.

In case of surgical treatment of the limited burn areas, most of the surgeons consider that after necrectomy and hemostasis, it is more viable to cover the wound surface with mesh autografts which have better drainage capacity. It stops development of blood lakes under them. Mesh index 1:1 which is called ‘plasty with mesh graft without elongation’ is used by many surgeons. After the surgery, a “hardly visible” net-shaped skin picture remains. However, a long-term result of mesh autoplasty even in absence of scar tissue does not meet the requirements of the patients, specifically on cosmetically vital and functionally active body parts as well as in case of 1-3% deep burns at any place. It is more appropriate to use thick unmeshed grafts. This issue is of paramount importance in child combustiology.

Some of the authors consider that local deep burns make 60 to 75% of the patients recorded with a heat injury and admitted to burns units.

A small injury area is usually not a reason for severe overall condition of patients. The ultimate goal of treatment is to obtain a positive functional and cosmetic result which satisfies both the doctor and the patient. This problem is specifically relevant at surgical treatment of burns in places not covered with clothes and which are functionally/aesthetically important (face, hands, back of the foot, etc.), especially in children.

Burns of the hand dorsum are a relevant problem in combustiology considering the importance of the functional zone for this damage. According to a few authors, this area is more often subject to heat damages compared to other structures. Burns of the hand dorsum are observed in 44% of the patients. The hand dorsum is a complex structure with uneven pattern which causes certain difficulties for treatment. However, the results of treatment require complete function recovery. Post-burn cicatricial deformity of the hand with joint contractures is one of the main reasons of disability: deep hand burns make up to half (48.5%) of all the cases of disability.

The hand and feet dorsa have a few common anatomic features: low skin mobility, thinner skin cover, thinned subcutaneous fat layer, superficial upper dermis, peripheral blood supply, slow venous and lymphoid outflow. These factors predispose to deeper skin damage in this place and tendency to cicatrization. Considering the importance of achieving positive treatment results in patients with burns of the hand and feet dorsa, it is vital to develop new methods of treatment.

Since 2015 we use a method for treatment of the hand and feet dorsa burns, which allows to: - improve early necrectomy with primary skin autoplasty; decrease intraoperative blood loss due to carrying out autoplasty under a tourniquet; decrease the surgery time for hemostasis before plasty; improve the cosmetic results in the post-operation period due to use of unmeshed split autografts.

The unique feature of this method is that when carrying out early tangential necrectomy of deep burns on the limbs, including the hand and feet dorsa, with the use of an arresting bleeding tourniquet, skin plasty with a split unmeshed graft is carried out under a tourniquet on the limb. The tourniquet is removed after applying a compressing bandage on the wounds.

Early necrectomy with primary autoplasty in patients with deep hand and feet dorsa burns (Figure 5.61) is carried out on the second day from the injury time, if there is no clinical presentation of the burn shock. Graft plasty without meshing is usually possible up to 7 to 9 days, if there is no inflammation in the wound. The surgery starts after preoperative preparation and treatment of the skin surgical area. Skin autograft (0.2 to 0.3 mm thick) sampling is carried out with an electric dermatome in places free from burns and with an area equal to expected necrectomy. Antiseptic bandages are applied on donor wounds. Autografts are covered in tissues wetted in antiseptics. Then an arresting bleeding tourniquet is applied on the shoulder of the injured limb, more proximal to the burn. Devitalized tissues are removed tangentially with an electric dermatome to the derma sublayers and mosaic parts of the exposed subcutaneous tissue (Figure 5.62).

There is no bleeding in this case. After visual assessment of complete necrosis removal, autoplasty is carried out with a split skin unmeshed graft (Figure 5.63). The graft edges are to be fixed with stitches. The hand and feet dorsa have an even and smooth pattern, so when applying antiseptic bandages, the graft does not shift and it is fit tightly against the wound. The edges are to be stitched in the area of fingers and bend of wrist and ankle joints. The wound is to be taped up with 5 to 7 rounds of medical bandage. The tourniquet is to be removed immediately after applying a compressing bandage and a splint. Tourniquet application time depends on necrectomy area and varies from 10 to 30 minutes. The surgery time decreases to 10 to 20 minutes which are required to carry out hemostasis before plasty without applying a tourniquet. In the post-operation period, an elevated position is arranged for the limb. The first dressing is applied on the third to fifth day. Complete adaptation of skin grafts is usually observed on the seventh to ninth days (Figures 5.64 and 5.65). In the future due to early surgical treatment and plasty with unmeshed grafts, no contracture or formation of scar tissue is observed, maximum and cosmetic results are achieved (Figures 5.66 and 5.67).

Figure 5.61. Second day after a flame burn injury, generation of a deep burn eschar.

Figure 5.62. Necrectomy is carried out to the derma sublayers under a tourniquet, no bleeding.

Figure 5.63. Autoplasty with unmeshed grafts is carried out.

Figure 5.64. Good graft adaptation in seven days.

Figure 5.65. Joint movement is completely retained.

Figure 5.66. No scar tissue in one year.

Figure 5.67. A positive functional and cosmetic result is achieved.

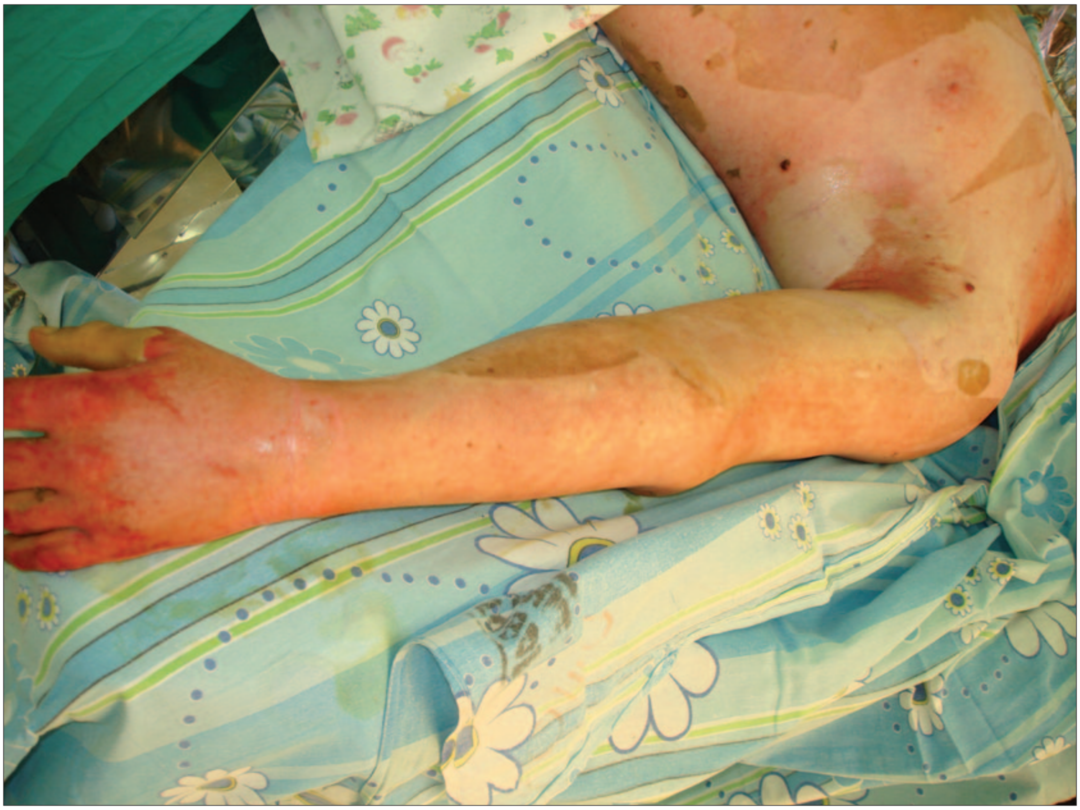


Figure 5.68. Third day after 3rd degree flame burn to 30%. An eschar is generated.

Figure 5.69. Skeletal suspension is carried out.
Early tangential necrectomy on upper limbs up to 15% under a tourniquet.

Figure 5.70. Primary autoplasty under a tourniquet on the hand dorsum without meshing, and with mesh ratio 1:4 on other wounds.

Figure 5.71. Mesh and biologic wound covering on autoplasty.

Figure 5.72. In one day, on the fifth day after the burn a surgical treatment of the body is planned.

Figure 5.73. To 15% of tangecial necrectomy reaching viable layer of the dermis.

Figure 5.74. Primary autoplasty with mesh ratio 1:4. Donor sites on lower limbs.

Figure 5.75. Biologic wound covering is applied on autografts.

Figure 5.76. In one week after the surgery, stage cell-like epithelization.

Figure 5.77. In two weeks the skin is recovered.

Figure 5.78. At early surgical treatment, skin recovery takes place 2 to 2.5 times faster, severe burn disease does not develop.

Success of aesthetic and plastic surgery led to increased requirements to the treatment results of burn patients in acute post-injury period.

There are different definitions of rehabilitation and stages of its provision. Rehabilitation is a process when a patient receives help in order to reach maximum potential after a disease or injury. There are three main types of rehabilitation: medical, which includes all remedial measures aimed at recovery of the patient's health, social and professional. Many authors agree that rehabilitation in combustiology includes both skin cover recovery and measures aimed at preventing and eliminating scar tissue for cause.

A system of medical rehabilitation of the heat burn patients is provided in all the burns units and centers in Russia. The rehabilitation system is provided during all the periods of burn disease in three stages. The first stage takes place at acute injury period and involves fastest stabilization of the patient's state and recovery of the skin cover integrity. The second stage is aimed at conservative treatment. And the third one is surgical rehabilitation.

Up to 35 to 40% of adult burn patients later require reparative-recovery operations and different rehabilitation actions. In children combustiology around 70% of children require dispensary observation, 7% of which become disabled, 20 to 40% of the injured require recovery surgical treatment.

Complete recovery of functions and return to physical, social and psychological health which was present before the disease or injury is the desired scenario. Recovery of complete psychological health disrupted because of inevitable cosmetic defect in patients with deep burns is an actual task of combustiologists, recreation therapists, psychologists and doctors of other specialties.

Epithelization of burn wounds in three weeks leads to growth of scar tissue. Early use of compression clothes starting immediately after autoplasty is considered to be efficient. It is necessary to use pressure garments for at least six months in order to reduce vascularization, thinning and flattening of scars.

Health resort treatment and after care are important to exclude generation of scar tissue. However, combustiology in Russia is not in the Federal catalogue of specialties where the patients are provided with free health resort treatment.

Upon discharge, the patients use compression and removable splints for at least one year together with physiotherapy and exercise therapy. Creams and ointments are applied locally for scar tissue wetting. It is important to use products with silicone which is included in the international standard of anti-scar therapy.

The results of treatment in functional and cosmetically important areas are assessed by the patients in the first place. The patients do not pay attention to medical scales of scar generation. Some patients treat the pattern of skin graft after the injury as a life drama, even if there is no scar tissue.

The maximum functional and cosmetic treatment results comprise three components:

First component: treatment in acute period after the injury (ideally: early surgical treatment; graft plasty without meshing; fast skin cover recovery; minimum wound inflammation and abscess; patients' positioning).

Second component: conservative scar treatment, especially in the first year of epithelization (compression, splints, physiotherapy, exercise therapy, health resort treatment and anti-scar products).

Third component: individual predisposition to cicatrization.

Doctors and patients can affect and control the first and the second components, but not the third one.

Therefore, the most important task when treating the patients with burns in functional and cosmetically important areas is to obtain both functional and cosmetic results, which first of all satisfy the patient but not the doctor. It is desirable to analyze and develop new methods of surgical treatment.

Figure 5.79. Fourth day after boiling water burn, severe burn injury; early necrectomy with primary plasty to 15% is planned.

Figure 5.80. Treatment with Plazmoran during five minutes in order to decrease the wound microflora.

Figure 5.81. Treatment with Plazmoran after necrectomy under a tourniquet for local hemostasis.

Figure 5.82. After obtaining skin autografts which are meshed with mesh ratio 1:4.

Figure 5.83. Primary skin autoplasty on the left thigh.

Figure 5.84. UniformPran is applied on plasty.

Figure 5.85. Appearance of the abdomen wound after necrectomy.

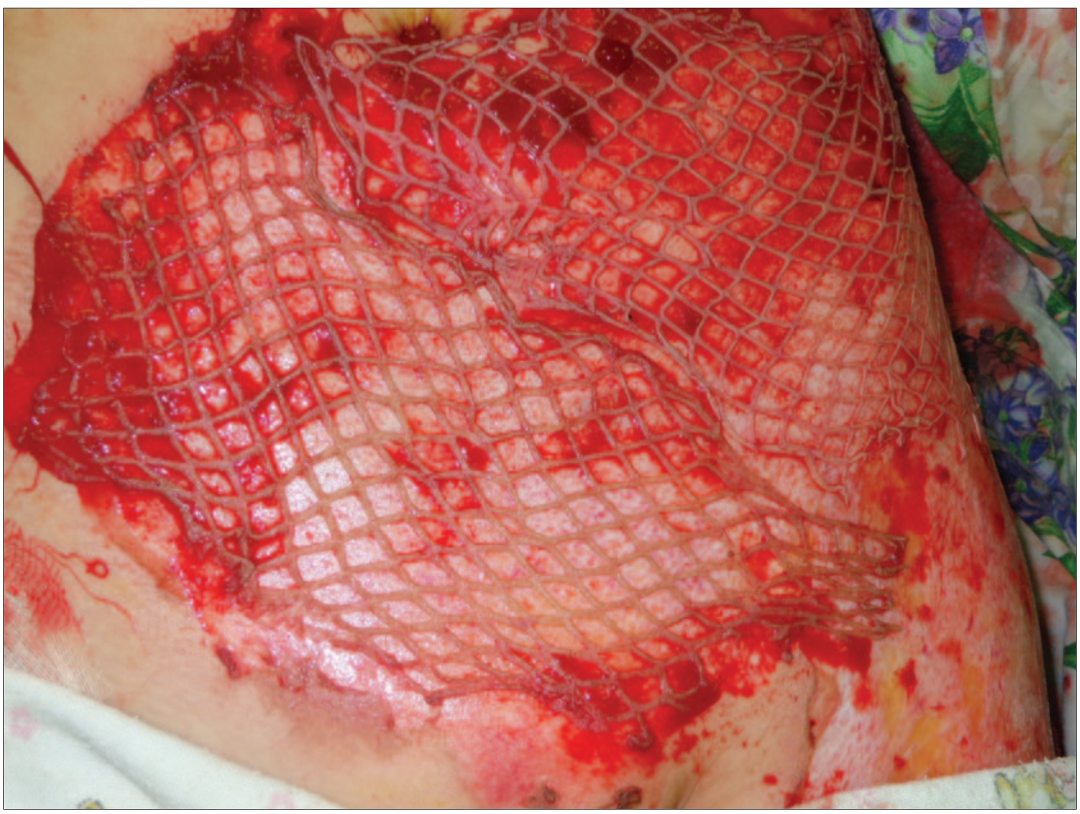


Figure 5.86. Plasty on the anterior surface of the abdomen.

Figure 5.87. All wound surfaces are covered with ChitoPran.

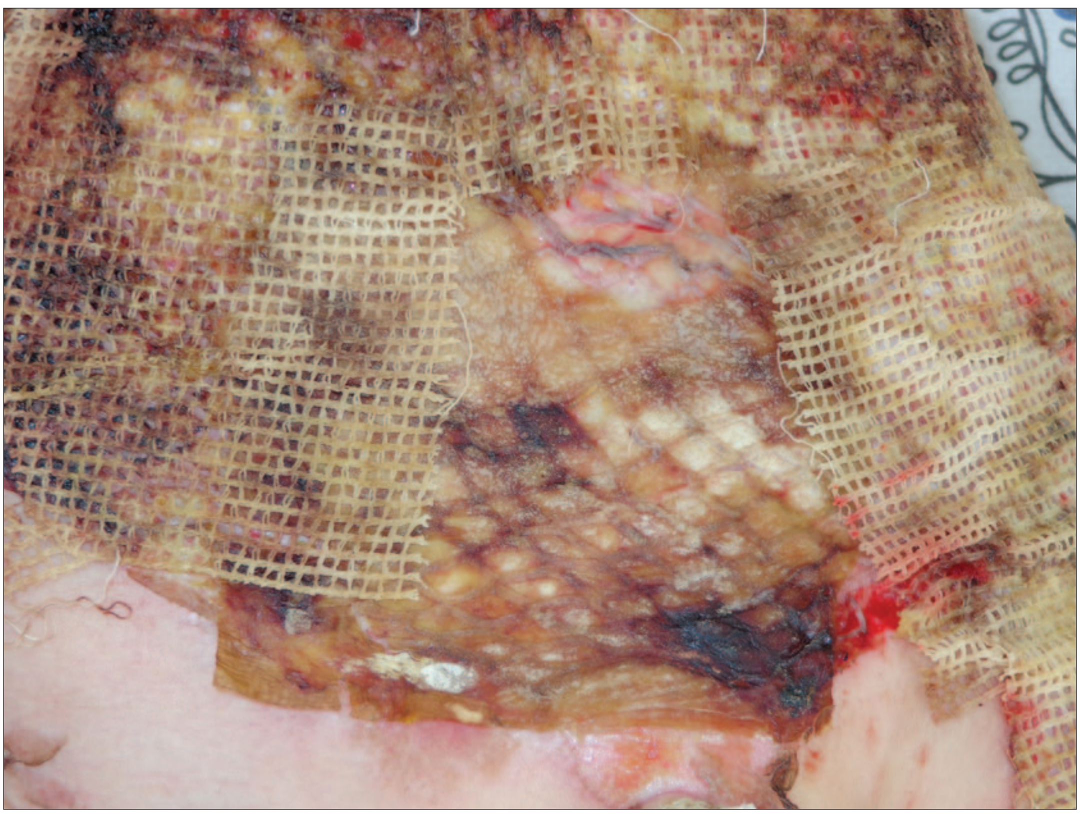


Figure 5.88. Stage epithelization under wound dressings, fifth day after the surgery.

Figure 5.89. Tenth day after the surgery, cell-like epithelization in dehydrated medium.

Figure 5.90. Treatment outcomes in two weeks.

Figure 5.91. Fifth day after a combined injury. Road traffic accident, blunt abdomen injury, flame burn. Median abdominal incision is carried out through the burn.

Figure 5.92. Tangential necrectomy is carried out up to 18% of the body surface with a necrotome against the laparotomy stitches.

Figure 5.93. Primary autoplasty with mesh ratio 1:4 is carried out.

Figure 5.94. UniformPran is applied in order to create optimal conditions for graft acceptance and cell-like epithelization in dehydrated medium.

Figure 5.95. Appearance of the wound in a week; stage epithelization under ChitoPran.

Figure 5.96. In 2.5 weeks the burn wound epithelized due to dehydrated medium, the laparotomy stitch did not go to pieces against the burn.

In case the patients have severe thermo-inhalation injury, placement of the tracheostomy tube is required; however, the deep neck burn limits this procedure. We have developed the 'Method of treatment the inhalation injury in combination with neck burns' in order to improve treatment of patients with deep neck and face burns together with thermo-inhalation injury, to improve tracheostomy procedure in patients with inhalation injury together with neck burns, to decrease the period of neck skin cover recovery in case of 3rd degree burns, to decrease the risk of suppurative complications after tracheostomy due to carrying it out through the recovered skin cover.

The tracheostomy method implies the following: in case of a burn, at first necrectomy is carried out in the trachea projection on the area of up to 0.5% of the body surface within sound tissue in depth with single-step autodermoplasty. Once autodermal graft is accepted, transcutaneous dilatation tracheotomy is carried out for adults, and surgical tracheotomy – for children.

The treatment of inhalation injury in combination with neck burns is carried out as follows. After anti-shock therapy in 24 to 72 hours after the injury, a standard preparation and treatment of the surgical area is carried out (Figure 5.97). Necrectomy of the neck burns is carried out within sound tissue in depth, hemostasis (Figure 5.98). Split skin autograft sampling is carried out as well as autodermoplasty; bandages are applied (Figure 5.99). In three to five days the state of skin autografts is assessed during the first dressing (Figure 5.100). The skin grafts are usually accepted on the seventh to ninth day (Figure 5.101). After that, a planned transcutaneous dilatation tracheotomy is carried out for adults in the operating room (Figures 5.102 and 5.103).

Figure 5.97. Third day after a severe thermo-inhalation injury and deep neck burns.

Figure 5.98. Tangential necrectomy is carried out to vital layers.

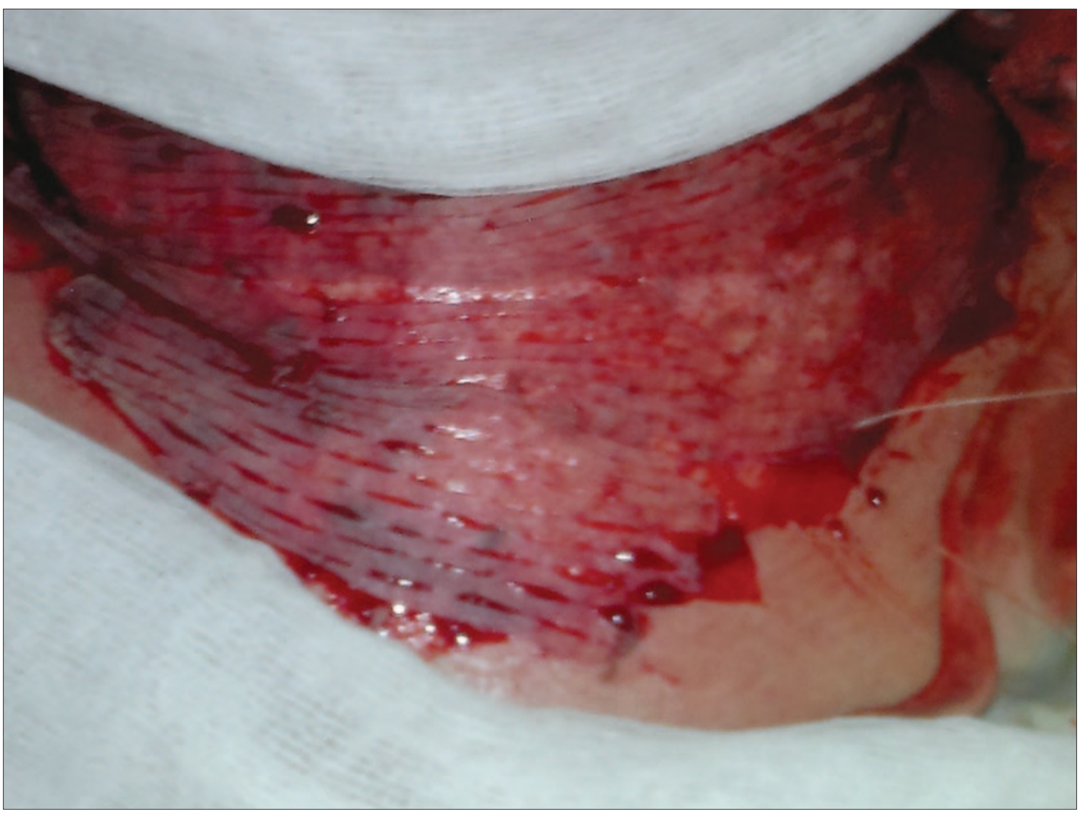


Figure 5.99. Primary skin autoplasty is carried out with mesh grafts without elongation.

Figure 5.100. In four days the neck edema diminishes; step skin adaptation.

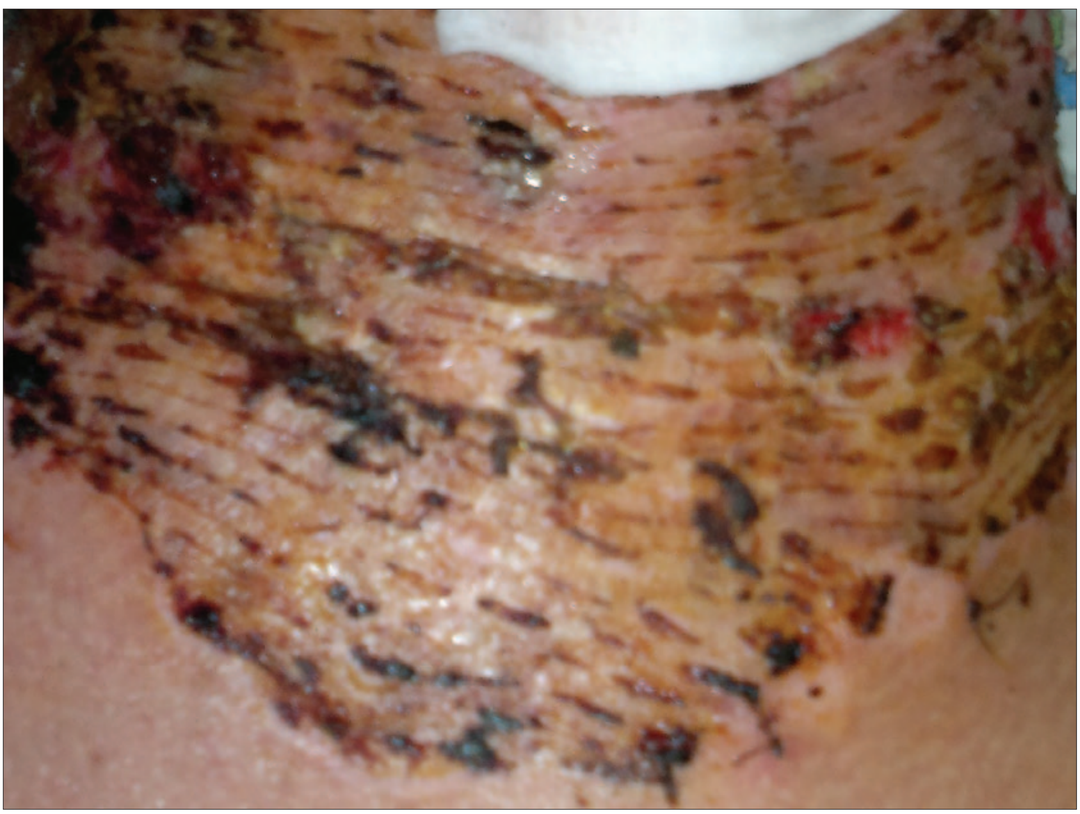


Figure 5.101. Primary plasty adopted in 7 days.

Figure 5.102. A kit for dilatation tracheostomy.

Figure 5.103. Artificial pulmonary ventilation is carried out through dilatation tracheostomy.

5.4.3. Electrical burns

Electrical burn is severe trauma, which requires long multi-stage treatment. Clinical picture is different and depends on the voltage of electrical burn. Moreover, electricity induces specific general and local injury.

Domestic electricity (220 volts) usually induces local electrical burns. Voltage of several thousand volts, if the victim survives, results in various electrical injuries depending on the way, which electrical current passes through patient's body.

Diagnosis depends on the type of injury. General influence on the body leads to electrical trauma, cognitive challenges, and heart disorders. Local influence leads to a burn. Clinically, burns caused by electricity are divided into three types: electrical burn – direct damage of patient's body from passed electricity; – electrical burn by voltage arc (mosaic depth of injury caused by arc lightning); – electrothermal burn –electrical burn is accompanied by clothes burning.

Local injury is characterized by mosaic depth of injury, when proximal from electricity entrance/exit skin, is not damaged, and electricity goes inside the body following a path of least resistance (neurovascular bundles, tendons and/or muscles).In this case, staged necrectomies, dynamic observations, preservation of deep anatomical structures are provided.

The separate issue is so called "carriage" injury. This kind of injury usually occurs when grow-ups climb the roof of train carriages, and it is enough to be at the distance of 2-5 meters from a high-voltage source (even not touching wires) to get extensive deep tissue electrical traumas and burns. Generally, this trauma is combined because victims fall from roofs of carriages and get mechanically injured.

All victims, clinically observed in this chapter, survived, but acquired a disability of various degrees.

Figure 5.104. The child took an exposed wire of domestic electricity (220 volts) in his hand. 3 days after the injury.

Figure 5.105. Necrectomy is performed, joints and tendons are exposed .

Figure 5.106. Artificial syndactyly is performed, plasty using adipo-cutaneous flap is indicated.

Figure 5.107. Italian plasty is performed (double pedicle flap – to fingers II-IV, U-shaped to the first finger).

Figure 5.108. In 3 weeks pedicles are gradually removed, secondary sutures

Figure 5.109. Artificial syndactyly is kept, finger are saved.

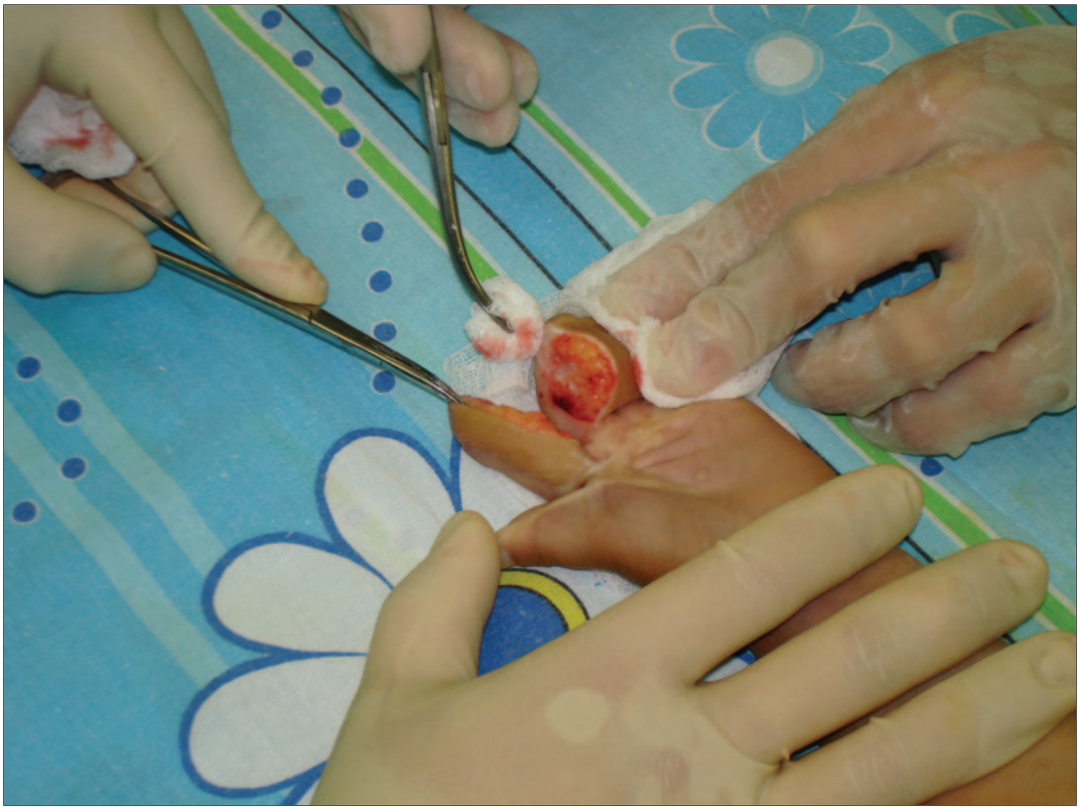


Figure 5.110. In a month, the first artificial syndactyly is separated following stabilization of the blood flow in the adipo-cutaneous flap.

Figure 5.111. Primary suturing of adipo-cutaneous flap.

Figure 5.112. The donor site on the back in 1.5 months after the surgery.

Figure 5.113. The second artificial syndactyly is separated in a months following the last surgery.

Figure 5.114. Day 2 after electrical traumas, electrical burn. «Broke into» a high-voltage transformer, miraculously survived.

Figure 5.115. There are mionecroses in necroctomic incisions carried out in regional hospital within the first hours after admission.

Figure 5.116. The “crater-shaped” injury – entrance and exit of high voltage.

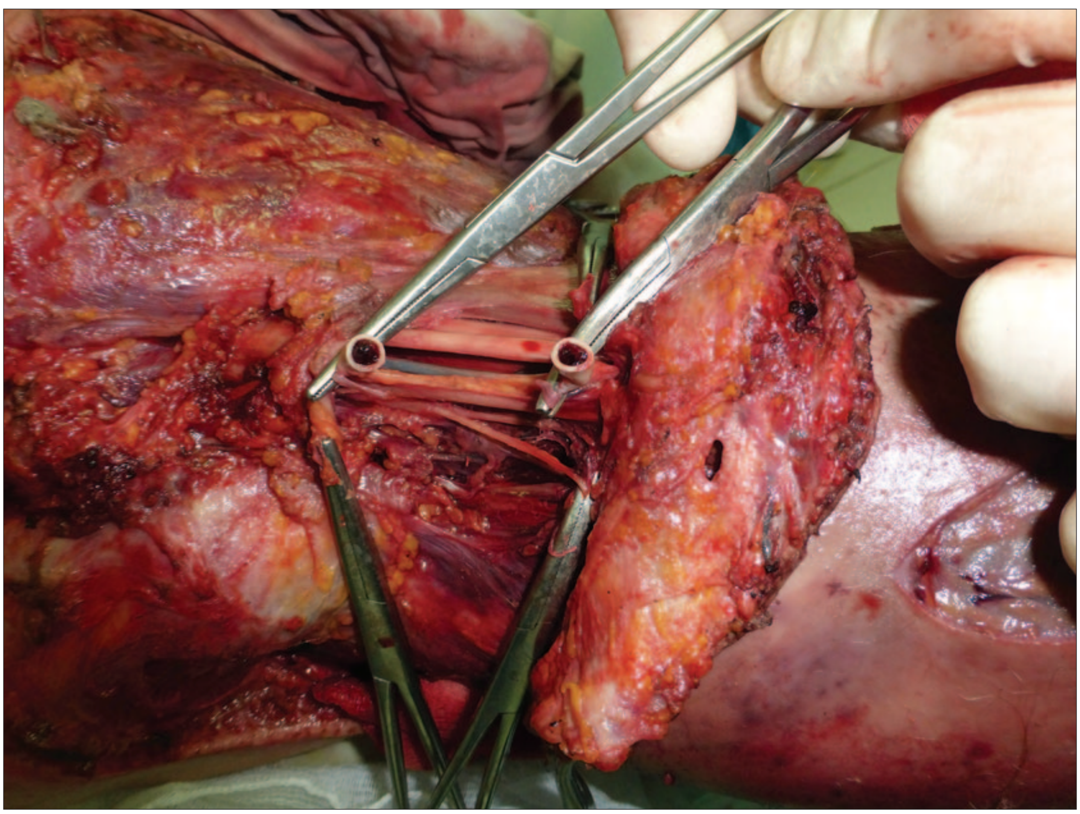


Figure 5.117. While performing bilateral exarticulations for the treatment of life-threatening conditions, thrombosis in the major vessel is observed.

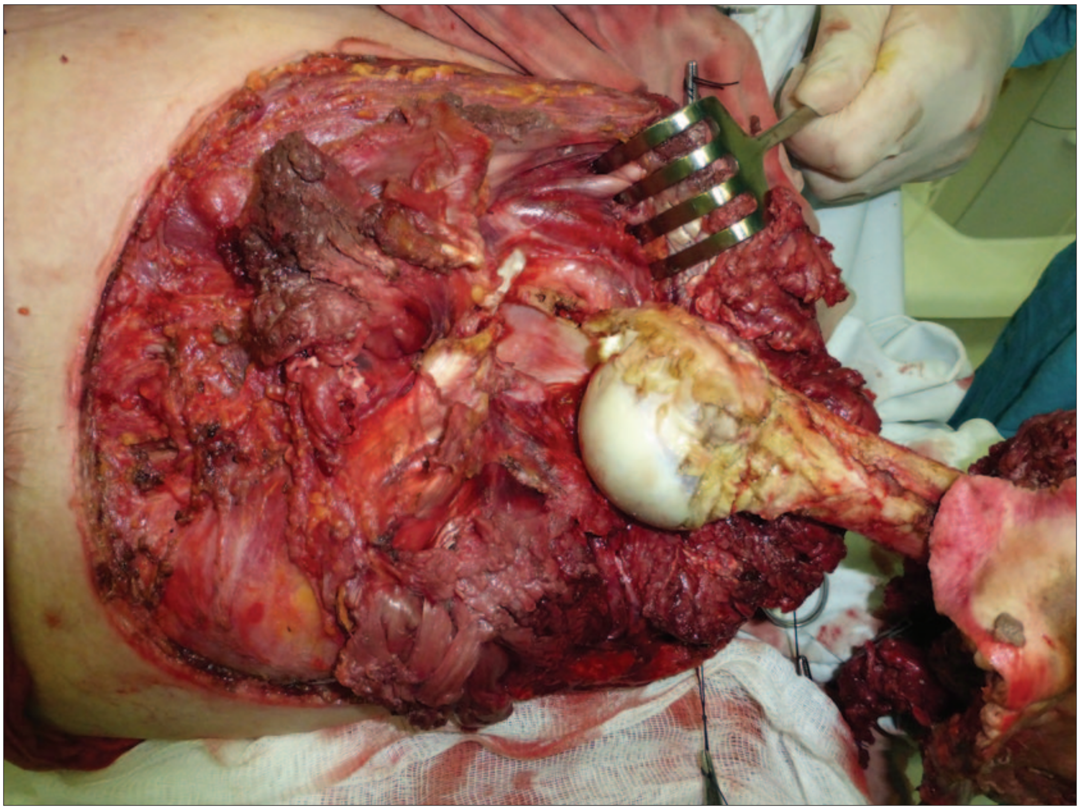


Figure 5.118. Surgical stages – exarticulation of the upper extremities with previous placement of the dressing on the subclavian vessels.

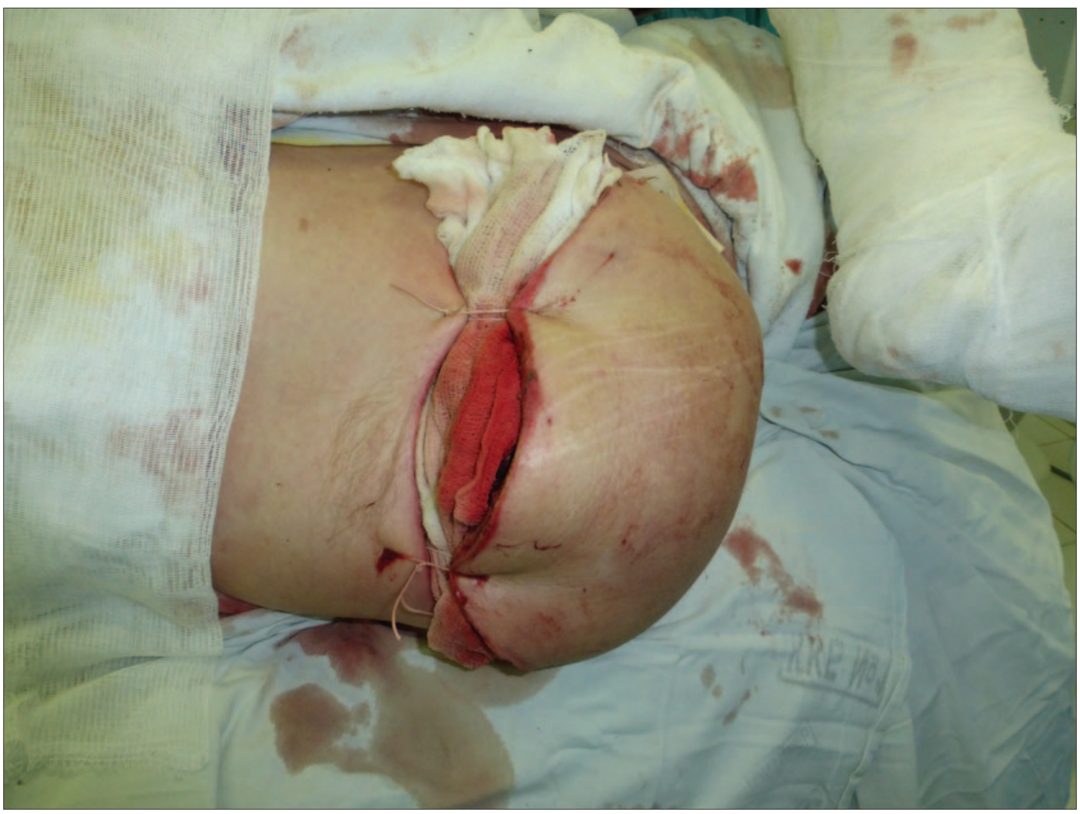


Figure 5.119. Loose apposition sutures are placed.

Figure 5.120. He held the fishing rod in his hand and cast it under high-voltage wires.

Figure 5.121. 3 days after the injury. Mummification of the hand, mosaic injury of upper extremities.

Figure 5.122. Guillotine amputation without suturing.

Figure 5.123. Since 1 week, mosaic mionecrosis of some muscular bundles is still observed.

Figure 5.124. Revision of the formed mionecrosis areas is carried out.

Figure 5.125. Treatment outcomes in 1.5 months after the injury; staged necrectomies were performed.

Figure 5.126. The result of a high-voltage electrical burn, exit burn of the head (clinical case is represented in figures 5.126-5.137).

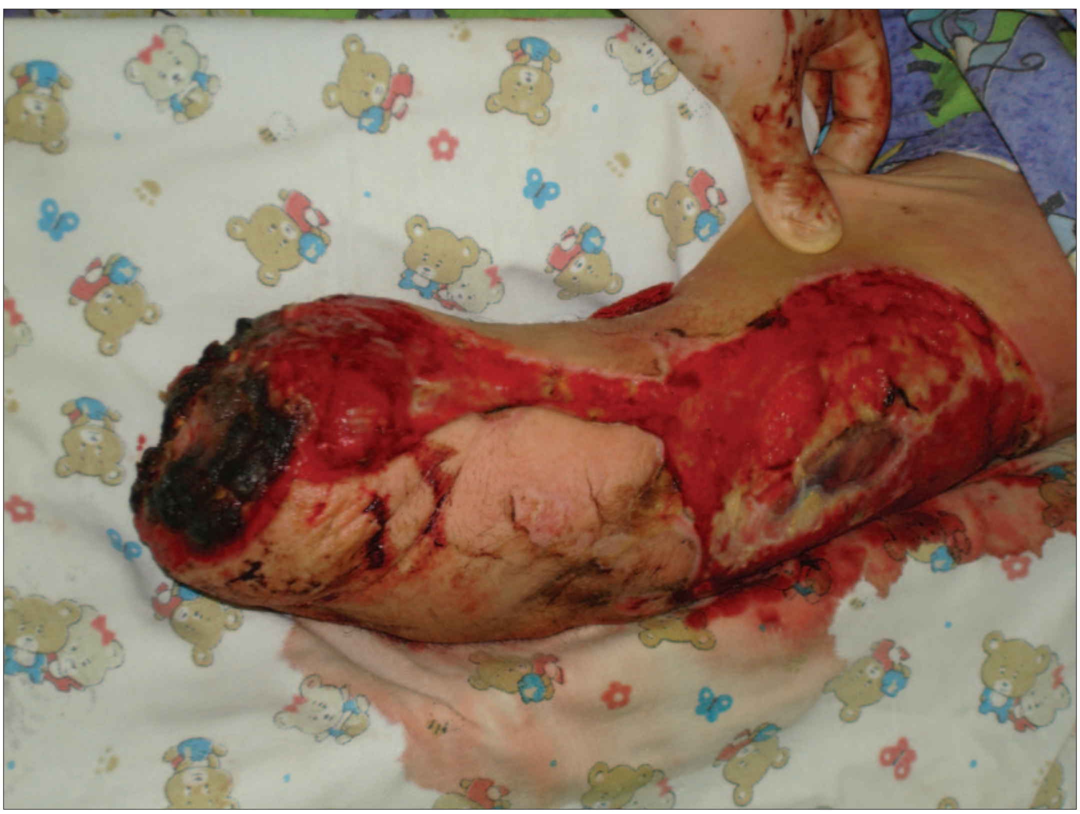


Figure 5.127. Exit burn of the lower extremity (current follows a path of least resistance).

Figure 5.128. Primary entrance on the right upper extremity with its mummification. Amputation has been already performed.

Figure 5.129. Necrectomy of the soft tissues in the upper part of the head is performed; non-viable aponeurosis.

Figure 5.130. Mosaic damage of the muscles of the upper extremities (mionecroses alternate with viable muscles).

Figure 5.131. Revision of the viability of neurovascular bundle of the shoulder.

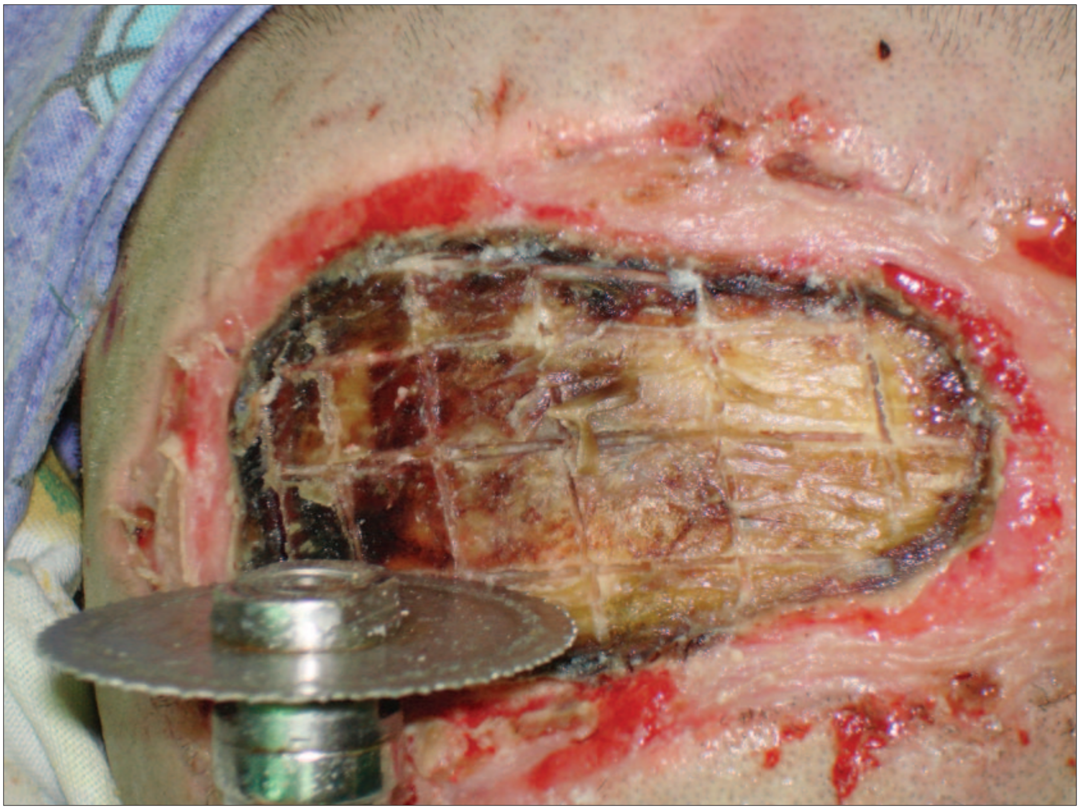


Figure 5.132. Osteonecrosis formed on the head in 2 weeks; incisions are carried out to evaluate the viability of the bone structures.

Figure 5.133. Osteonecrectomy after checkerboard cuttings.

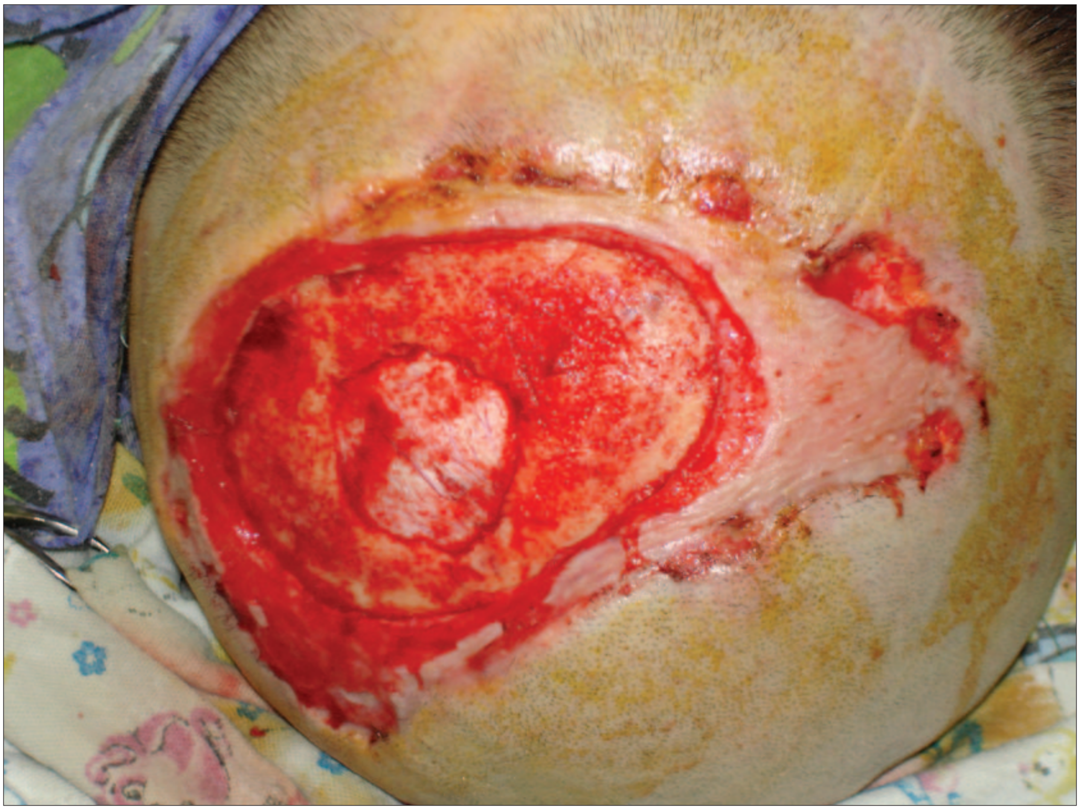


Figure 5.134. Exposed viable area of the dura.

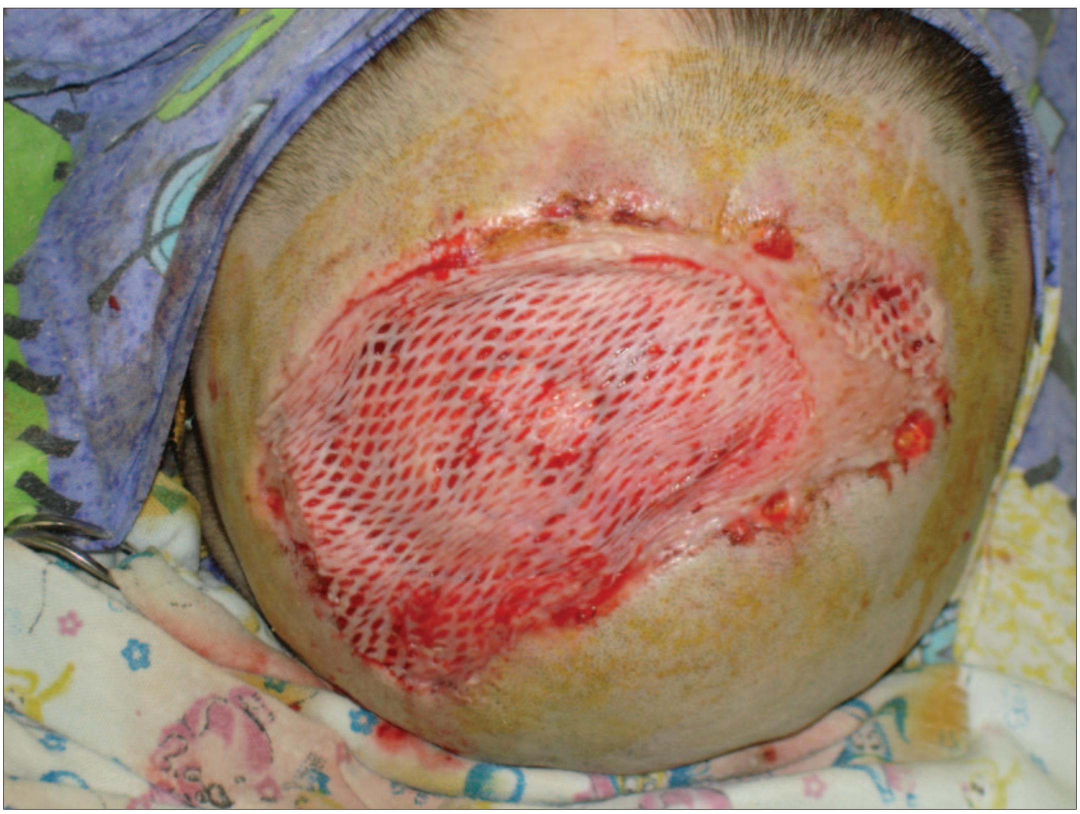


Figure 5.135. Autoplasty using a split-thickness graft placed on the dura and bone structures.

Figure 5.136. Treatment outcomes in 1.5 months – the right upper extremity is saved at the level of the middle third forearm.

Figure 5.137. Adaptation of autotransplants on the head.

Figure 5.138. «Carriage trauma» (case 1, figures 5.138 - 5. 144).
The 4th day after the injury. There is an arc burn involving up to 45% of the body.

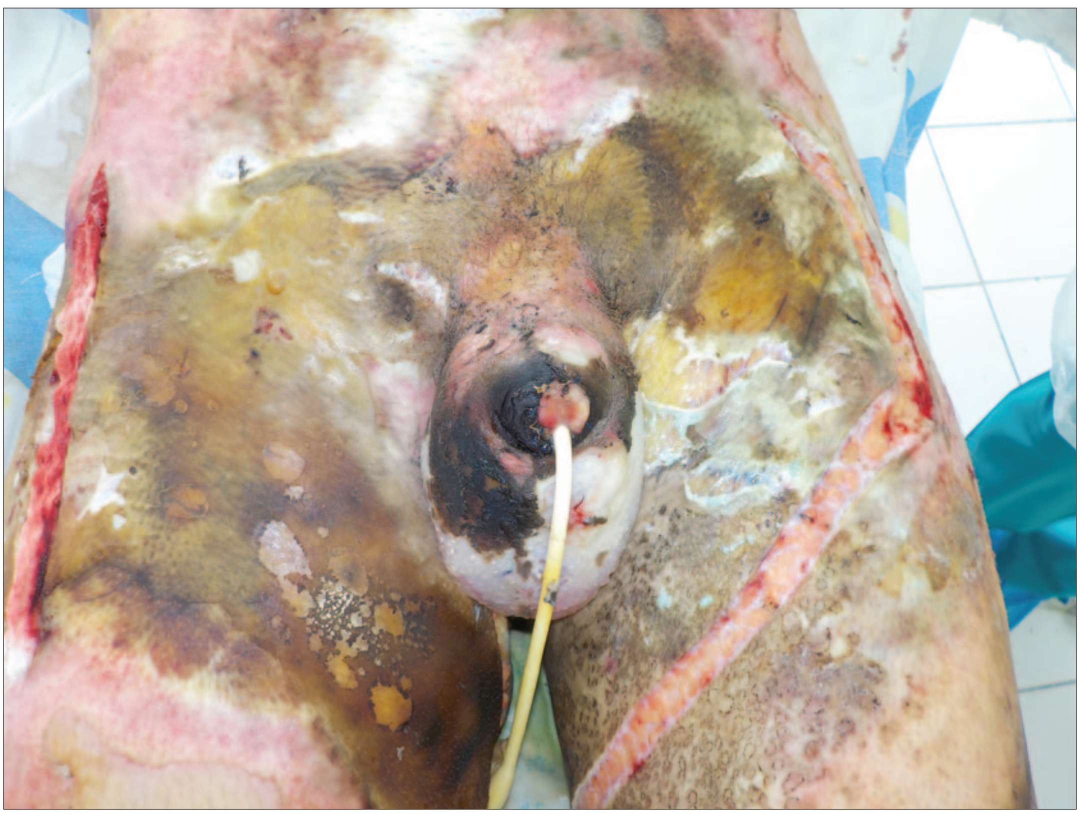


Figure 5.139. Exit of electricity in the groinal area is shown.
The 4th day after the injury. Early surgical treatment is planned to save patient's life.

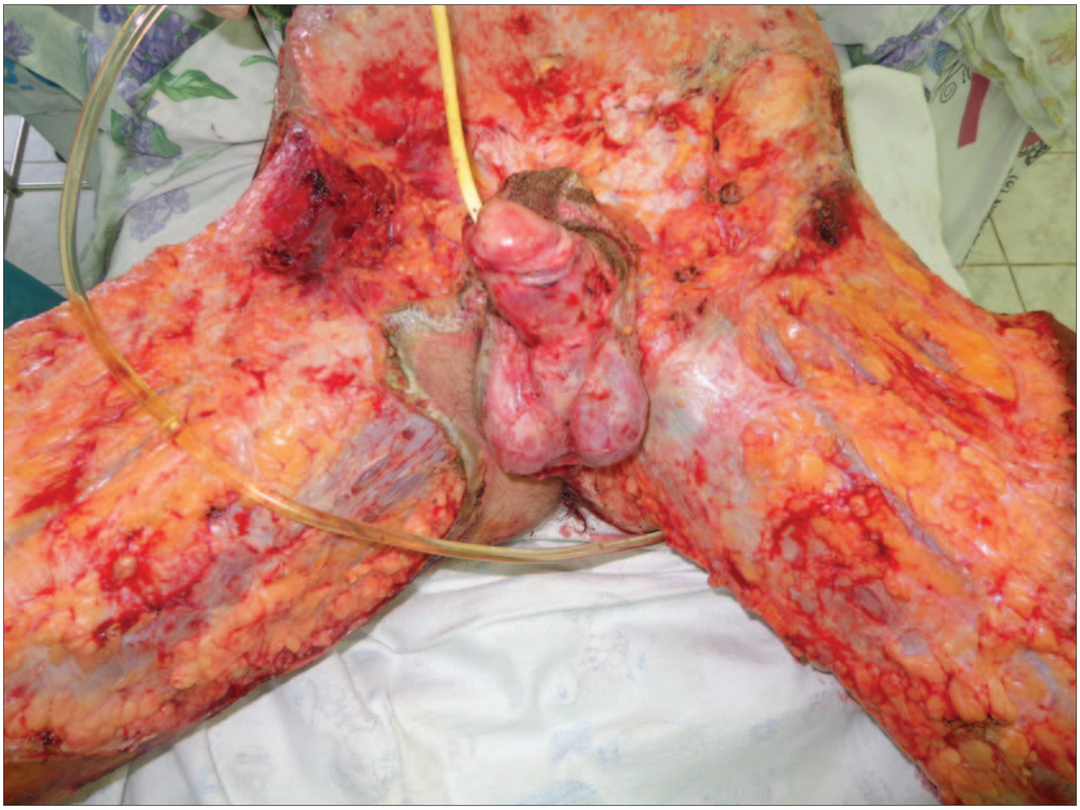


Figure 5.140. Fascial necrectomy to viable areas is performed.

Figure 5.141. 3 weeks after the injury. Serial surgeries are performed.

Figure 5.142. Granulation tissue is developed after fascial necrectomy.

Figure 5.143. The wound is ready for autoplasty in 17 days after the injury.

Figure 5.144. 2 months treatment outcomes. 14 surgeries were performed: necrectomy, debridement, autoplastic surgeries.

Figure 5.145. «Carriage trauma» (case 2, figure 5.145 - 5. 150). The 2nd day after the injury (raised his hand on a carriage). Up to 50% of the body is injured.

Figure 5.146. Electricity entered the left lower extremity (he did not touch wires, was electrocuted at a distance.)

Figure 5.147. Current exits through the groinal area. Deep injuries.

Figure 5.148. Amputation of the left upper extremity is performed, loose suturing.

Figure 5.149. Staged preparation of the wound to autoplasty after fascial necrectomy.

Figure 5.150. Early necrectomy with primary autoplasty is performed on the body.

Figure 5.151. «Carriage trauma» (case 3, figures 5.151 – 5.156). Fortunately, he was not killed immediately, and there are no indications to amputation.

Figure 5.152. Fascial necrectomy of 25% of the body is performed.

Figure 5.153. All burn injuries were cleaned from necrosis during 3 surgeries (2, 4, 6 days).

Figure 5.154. Granulation tissue is developed within 10-14 days after necrectomy.

Figure 5.155. Autoplasty with a perforation index 1:4 is performed on the “ready wounds”.

Figure 5.156. 1 month after the injury. Autoplasty is performed on areas with deeper burn injuries after staged necrectomies.

Figure 5.157. «Carriage trauma» (case 4, figures 5.157 - 5. 162). 3 weeks after the injury. Deep wounds involves up to 60% of the body. All wounds were surgically treated.

Figure 5.158. Necrectomies with primary and delayed autoplastic surgeries with perforation index 1:4,1:6 and "UniformPran" were performed.

Figure 5.159. Staged epithelization under UniformPran. Skeletal extension on the extremities.

Figure 5.160. Size of cellular epithelization reaches up to 1.5 cm.

Figure 5.161. 2 months treatment outcomes. Autografts are harvested from all free of burns skin areas (including three times from the scalp).

CHAPTER 6.
ENHANCING THE APPLICATION OF VACUUM THERAPY IN SURGERY

6.1. Historical aspects of vacuum therapy in surgery.

The technique of directed negative pressure is widely used for treatment of various wounds in modern medicine. Vacuum therapy is one of the most old treatment techniques in the history of medicine. Many leading surgeons of the 19th century used vacuum for treatment of their patients. Works of outstanding German surgeon August Beir “Artificial Hyperemia as Treatment Technique” and “Passive Hyperemia Therapy” (1960) contributed much to the development of vacuum therapy. He associated medical effect of negative pressure on tissues not only with aspiration of purulent exudate, but mostly with improved local blood flow.

The following effects of vacuum therapy are distinguished: active removal of excessive wound fluid; the wound remains wet stimulating angiogenesis; faster decrease of bacterization of the wound tissues; reduction in local interstitial edema of the tissues, reduced intercellular pressure; better local blood supply; decline in the wound area; prevention of nosocomial infections, cost reduction. It should be noted, furthermore, that fast and effective wound treatment using vacuum therapy has a particular advantage of longer patient’s survival, better quality of life and lower number of wounds and systemic injuries, and also reduced costs of treatment. Nowadays, many types of professional equipment are used for vacuum therapy.

6.2. New methods of vacuum therapy.

In combustiology, due to various localizations, size and depth of injuries, vacuum therapy has a number of limitations associated with large areas and failure to fix the film on the burn. One of the most important advantages of vacuum therapy is the elimination of the wound odours.

To stimulate the growth of granulations, variable modes are set on the vacuum device, usually from 70 to 120 mmHg. The constant pressure modes staring from 100 mmHg is optimal for placing of vacuum on autoplasty.

This chapter represents new technologies of vacuum therapy in combustiology, their development is possible when combining various sponges and dressings from different vacuum systems. In 2019, Russian device for the vacuum therapy “VIT” (“VIT Ultra”, “VIT Mobil PLUS”, “VIT Mobil”, “VIT Mini”) appeared in the Russian market, and we hope that it will find its place in practical work of combustiologists.

Figure 6.1. Fifth day after the contact burn. 3d degree eschar is developing (7%)

Figure 6.2. Fascial and tangential nerectomies are performed.

Figure 6.3. Primary autoplasty using perforated grafts (1:4).

Figure 6.4. Vacuum dressing with uniform pressure 120 mmHg.

Figure 6.5. Grafts are completely adapted to the wound surface at the first change in 4 days.

Figure 6.6. 2.5 weeks postoperatively, before discharge

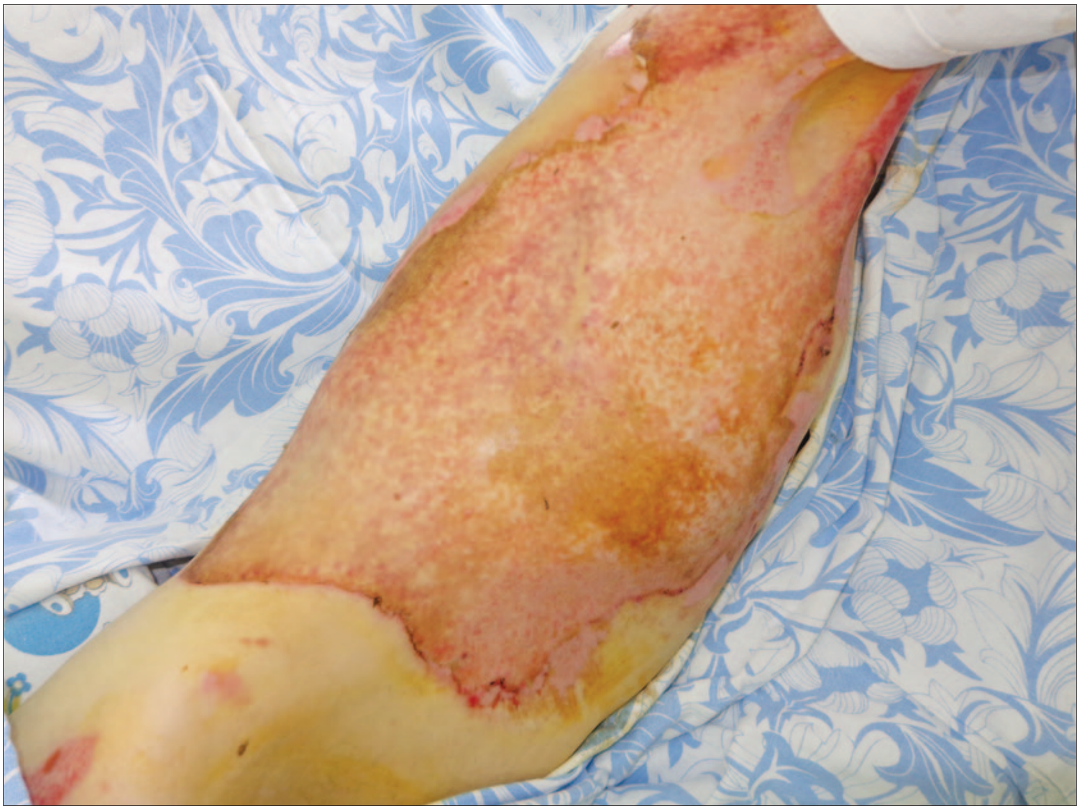


Figure 6.7. 3 days after the flame burn.

Figure 6.8. Tangential and fascial necrectomies to viable tissues are performed.

Figure 6.9. Primary autoplasty is fixed by Russian system «MEDSTEP».

Figure 6.10. Meshed covering “VoscoPran” with “Braunodin” is placed on the autograft with a perforation index 1:4.

Figure 6.11. Russian vacuum system “VIT Ultra” with constant pressure 100 mmHg is placed.

Figure 6.12. The fourth day after the surgery. Staged removal of the vacuum dressing.

Figure 6.13. Skin grafts are completely adapted to the wound surface.

Figure 6.14. In 3 weeks, before discharge.

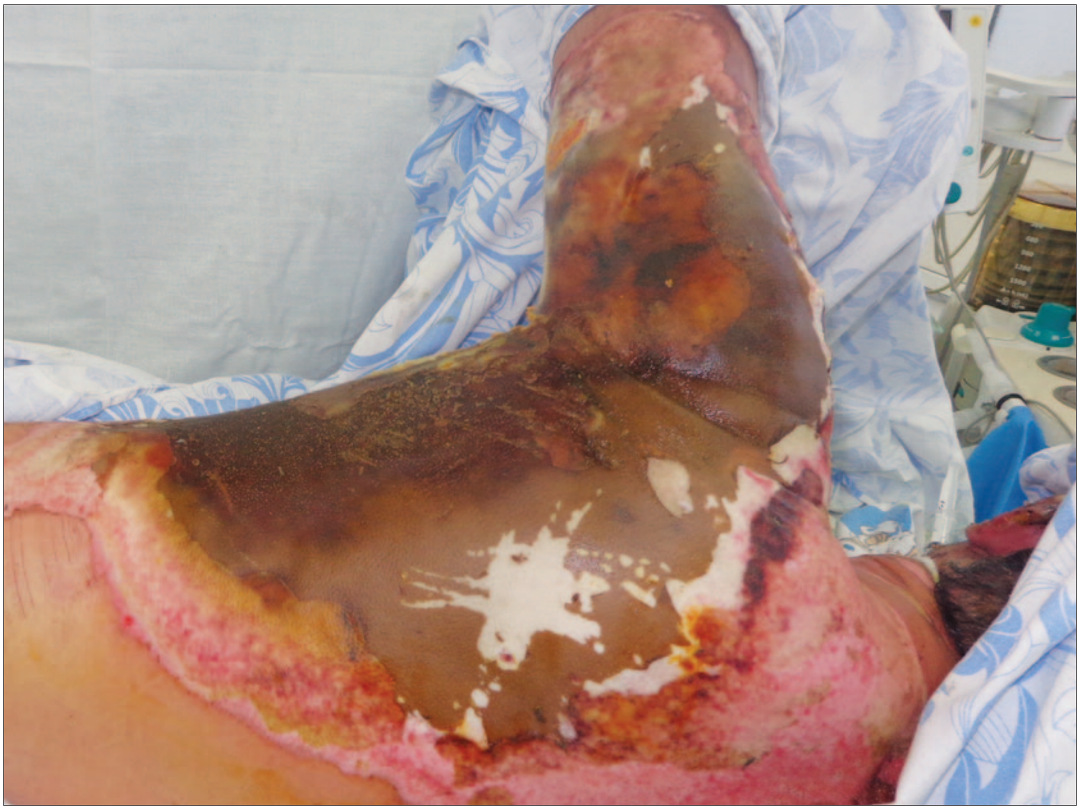


Figure 6.15. Deep flame burn.

Figure 6.16. Fascial necrectomy is performed.

Figure 6.17. Primary skin autografting harvested from lower extremities.

Figure 6.18. Vacuum dressing is placed on the body and shoulder.

Figure 6.19. It is recommended to have two assistants for placing of vacuum dressings.

Figure 6.20. Vacuum dressing allows lying on the wound. Transplantation creates optimal conditions for the adaptation of skin grafts.

Figure 6.21. The meshed wound covering and sponge are removed at the first change on the fifth day.

Figure 6.22. Good adaptation of grafts is observed even in uncomfortable localizations.

Figure 6.23. Treatment outcomes in a month.

To use vacuum therapy on large areas of the body, we developed a special technique. Objectives: to improve early necrectomy with primary autodermoplasty; improve placing of a wound dressing on the body; exclude formation of hematomas under skin grafts in the postoperative period; provide constant firm pressure on skin grafts; reduce treatment period; improve functional and esthetic outcomes; make it possible for a patient to lie on his wound.

The essence of the method including necrectomy, autodermoplasty, placing of a vacuum dressing, is the following: after necrectomy, wound margins are sutured in accordance with XL size of the dressing kit VivanoMed for a vacuum system Vivano. We stick film dressing Hydrofilm to the remaining eschar, creating a constant pressure 110-120 mmHg in a vacuum system for 3 days, and then we carry out necrectomy of the remained deep burns of the body with primary or delayed autodermoplasty.

Technical results: this technique makes it possible to fix a vacuum dressing on a burn eschar if one-stage necrectomy is impossible, stimulates the survival of free skin grafts with simultaneous plasty of wounds after necrectomy of more than 10% of the body area, provides comfortable position for a patient in bed after the surgery, reduce treatment period of deep burns of the body associated with fast engraftment of the transplanted skin, reduce the likelihood of wound dystrophy and septic complications in patients, speed up the preparation of wound to delayed autodermoplasty.

Clinical case. Patient S., 48 years old, was admitted to the burn department with a following diagnosis: 3d degree thermal burn (contact) of the body, extremities involving 17% of the body, burn disease with acute toxemia (Figure 6.24). On the 2nd day following the injury and stabilization of patient's general condition, he was brought to the OR. We prepared the operating filed in a standard manner (Figure 6.25). Then, we took skin autografts with a thickness of 0.3 mm using a powered dermatome. Dressings with hydrous solution (0,02% chlorohexidine solution) were placed on the donor wounds. The skin grafts were perforated with a perforation index 1:4. Devitalized tissues were removed with an electric scalpel (Figure 6.26) to the viable layers (superficial fascia, subcutaneous fat). Hemostasis was achieved. Wound margins were sewed with interrupted stitches (Figure 6.27) to reduce the overall size of the wound and make it equivalent to XL size of dressing kit VivanoMed for a vacuum system Vivano, 1800 sq cms. Then, we performed autodermoplasty (Figure 6.28). The skin autografts were covered with meshed wound dressings (Figure 6.29). After that, two sponges VivanoMed 30 x 30 cm were placed. We stuck dressing film Hydrofilm to the remaining eschar, established vacuum system Vivano (Figure 6.30) with constant pressure 100 mmHg for 3 days. In three days we performed next surgery, took off the dressing in the OR (Figure 6.32). There were no signs of festering under the wound dressing. After standard preparation of the surgical field, we performed necrectomy of the remained deep burns of the body (Figure 6.32). The granulation tissue formed in 7 days, on which we performed autodermoplasty using perforated grafts (Figures 6.33-6.34) taken from healthy areas. The dressing was changed in 5 days following autodermoplasty. We observed complete adaptation of skin grafts. And complete engraftment of skin the transplants after two stages of autodermoplasty on the 19th day after the injury.

Figure 6.24. Contact burn. He slept on the metal bars of a banya (Russian sauna) in a drunken state.

Figure 6.25. There are 3d degree burns on the anterior lateral surface of his body.

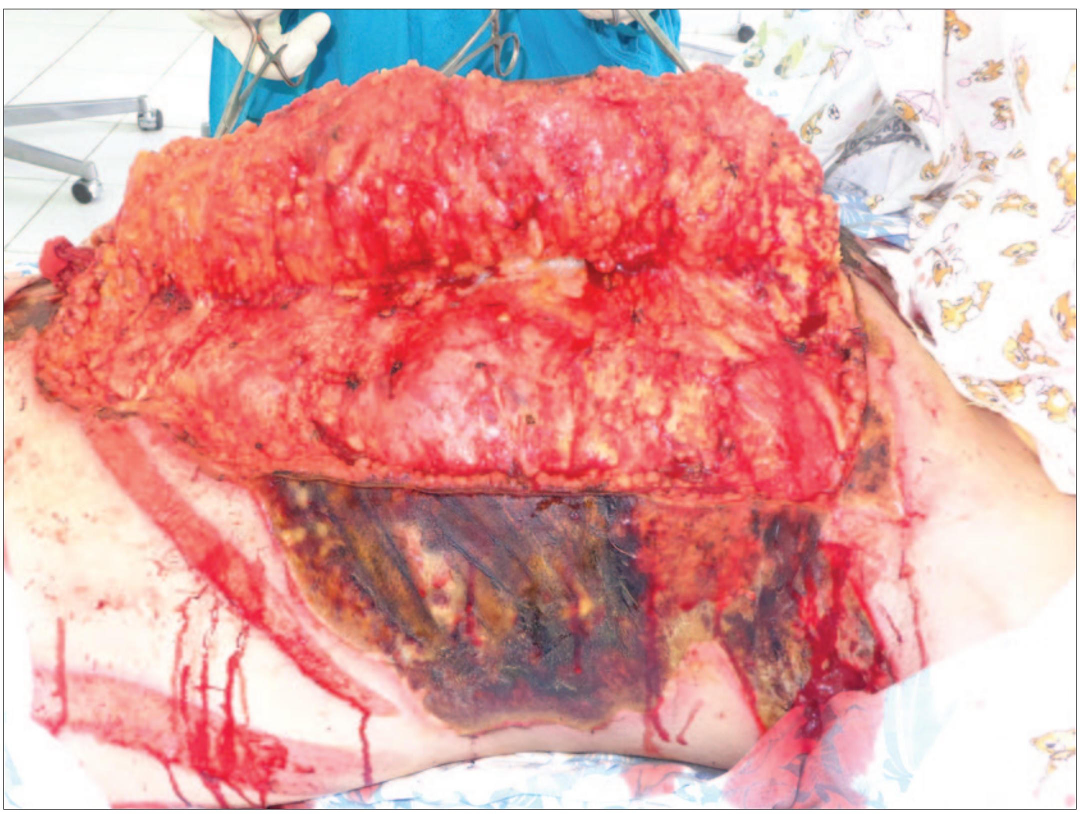


Figure 6.26. Fascial necrectomy on 1800 sq cms is performed.

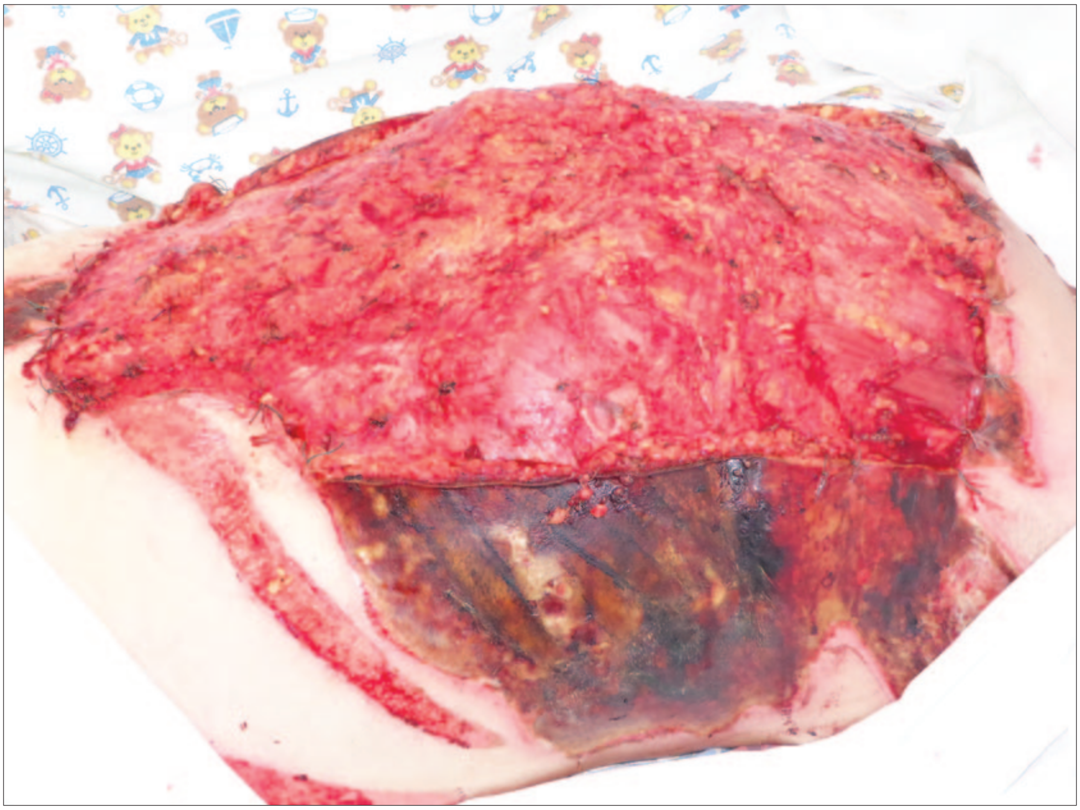


Figure 6.27. Wound margins are sewed with an encircling stitch.

Figure 6.28. Primary autodermoplasty with perforation is performed.

Figure 6.29. Meshed wound coverings are placed on autodermotransplants.

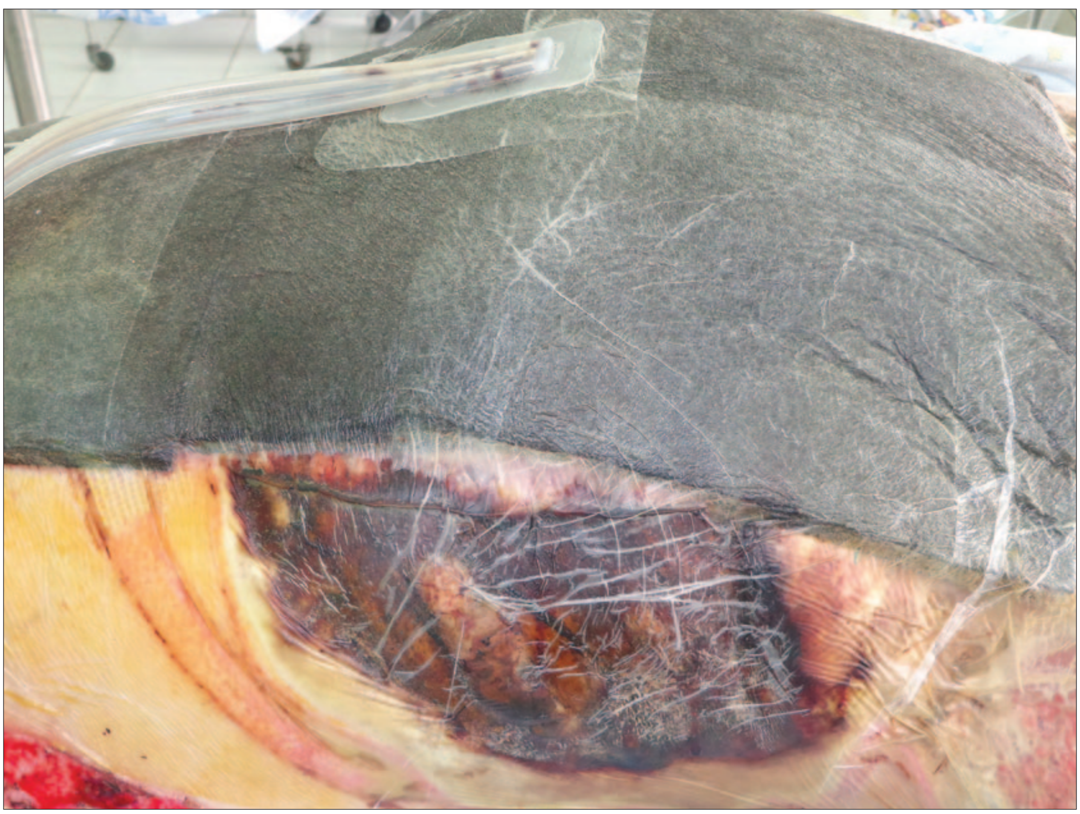


Figure 6.30. Vacuum dressing is placed on skin plasty with a film fixation both on the healthy skin and dry eschar.

Figure 6.31. Skin grafts are completely adapted in 3 days at the first dressing change.

Figure 6.32. The second surgery – necrectomy of deep burns is performed.

Figure 6.33. The granulation tissue is formed at regular dressing changes for 9 days.

Figure 6.34. While formation of the granulation tissue, the delayed plasty is performed.

Figure 6.35. Treatment outcomes in 19 days after the injury.

Figure 6.36. Delayed hospital admission. Osteonecrosis of the calvarial graft.

Figure 6.37. To estimate the depth of osteonecrosis, we made cuts in a checkerboard pattern.

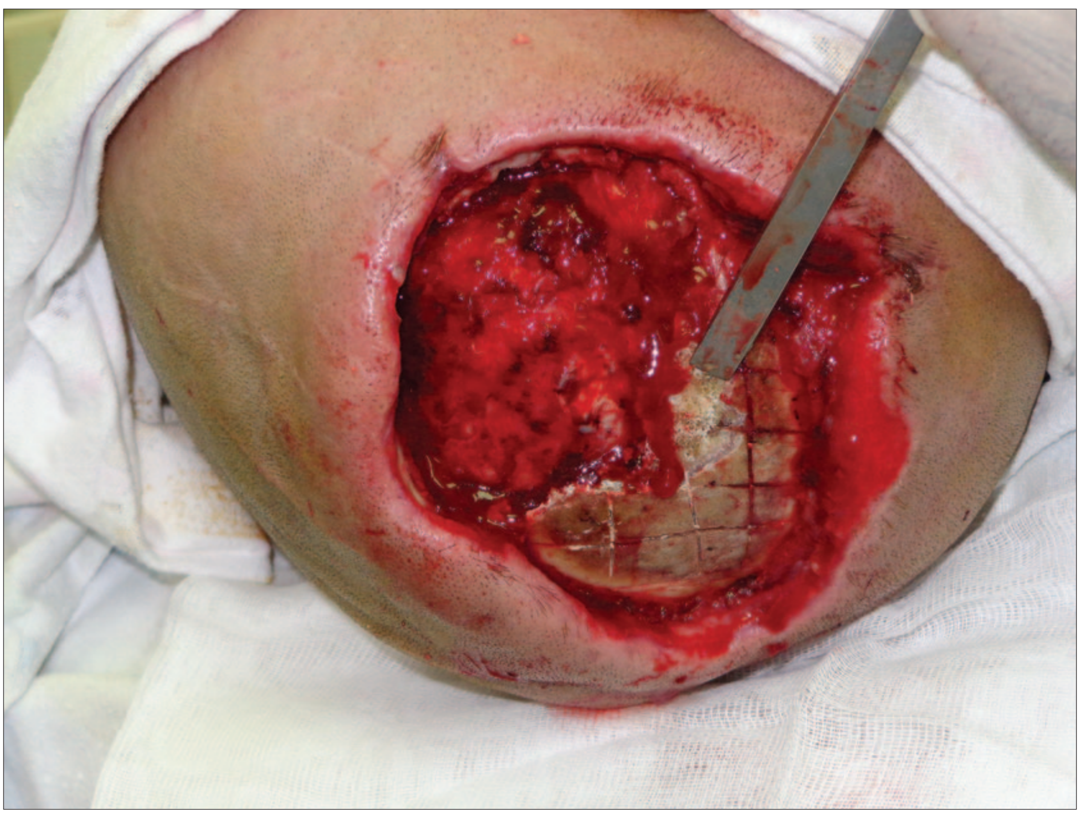


Figure 6.38. Osteonecrectomy to the dura, on which the granulation tissue has developed.

Figure 6.39. Skin autoplasty with a perforation 1:2 without stretching.

Figure 6.40. A vacuum dressing with a constant pressure 70 mmHg is placed.

Figure 6.41. At the first dressing change in 5 days, we noticed the good adaptation of the grafts.

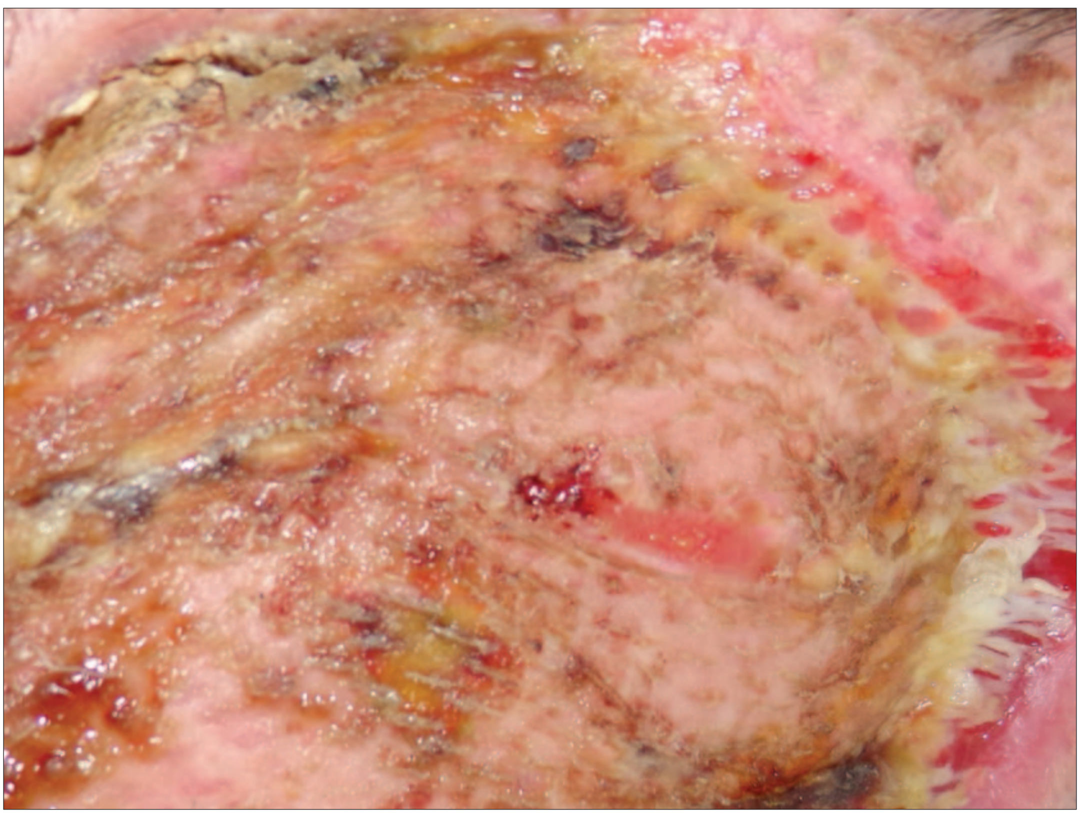


Figure 6.42. Treatment outcomes before discharge, 2 weeks after the surgery.

To improve placing of a vacuum dressing during early surgical treatment on the extremity, we offer the treatment technique. Objectives: to improve the placement of dressings; improve the technique of early necrectomy with primary plasty; exclude hematomas under transplants in the postoperative period; guarantee constant firm pressure on the operated extremity; improve functional and cosmetic outcomes.

The essence of the technique: after early tangential necrectomy with simultaneous skin autoplasty of the extremity using a tourniquet, we place antiseptic dressing. Then the wound is firmly bandaged in 2-3 steps using Kerlix AMD produced by Lohmann&Rauscher. When the extremity is bandaged, we place a special sterile bag for the vacuum apparatus Suprasorb CNP Easy Dress produced by Lohmann&Rauscher of the corresponding size on the extremity and localization (sizes are pre-defined by a manufacturer, Lohmann&Rauscher). Suprasorb CNP Easy Dress for the vacuum is fixed to the healthy skin using incision film Suprasorb F, and then we connect the vacuum that creates constant negative pressure 90-119 mmHg. The first dressing is changed in 2-3 days, the vacuum system is removed, wet-to-dry antiseptic dressings are placed. Engraftment is usually observed in 5-7 days.

Technical results: placing of a pressure dressing Kerlix AMD produced by Lohmann&Rauscher with subsequent connection to the vacuum system, maintains firm contact between the graft and prepared wound bed after necrectomy. This technique provides constant pressure on the extremity that prevents “running knots” and interruption of distal circulation. Moreover, using of vacuum therapy almost entirely prevents formation of hematomas under a graft.

Clinical case. Patient K, 35 years old, was admitted to the burn department with a following diagnosis: 2-3d degree thermal burn (flame) of the face, neck, both extremities involving 7% of his body. There is a deep burn of the dorsal surface of the hand in three days following the injury (Figure 6.43). The patient was brought to the OR, under general anesthesia, after standard preparation of the operating fields, we harvested skin autografts (0.2-0.3 mm) from the lateral surface of the right thigh with a powered dermatome. Using a necrotome, we excised the eschar of the dorsal surface of the left hand, including phalanges, to the lower viable dermis (Figure 6.44). Hemostasis was achieved. Then we performed autoplasty using free full-thickness skin autografts of the dorsal hand (Figure 6.45). After that, we placed meshed wound dressings (Figure 6.46), the wound was firmly bandaged in 2-3 steps using Kerlix AMD (Figure 6.47). Then we put a special sterile bag for vacuum system Suprasorb CNP Easy Dress on the extremities, connect vacuum through the port and set necessary pressure mode (Figure 6.48). Vacuum dressing was removed in 3 days. Engraftment is usually observed in 5-7 days (Figure 6.49). Due to placing of vacuum system after autodermoplasty on extremities, we managed to avoid displacement of a transplant and hematomas under it

Figure 6.43. Formation of the deep eschar is observed in 3 days after the scald injury.

Figure 6.44. Tangential necrectomy to the viable layers is performed under the tourniquet.

Figure 6.45. Primary plasty without perforation.

Figure 6.46. Meshed wound coverings are placed on the graft.

Figure 6.47. Hand is wrapped up with Kerlix AMD

Figure 6.48. Vacuum dressing is placed with a uniform pressure 120 mmHg on the extremity using a special bag.

Figure 6.49. Graft has completely adapted on postoperative day 5.

Figure 6.50. Post-burn scar contracture of the neck.

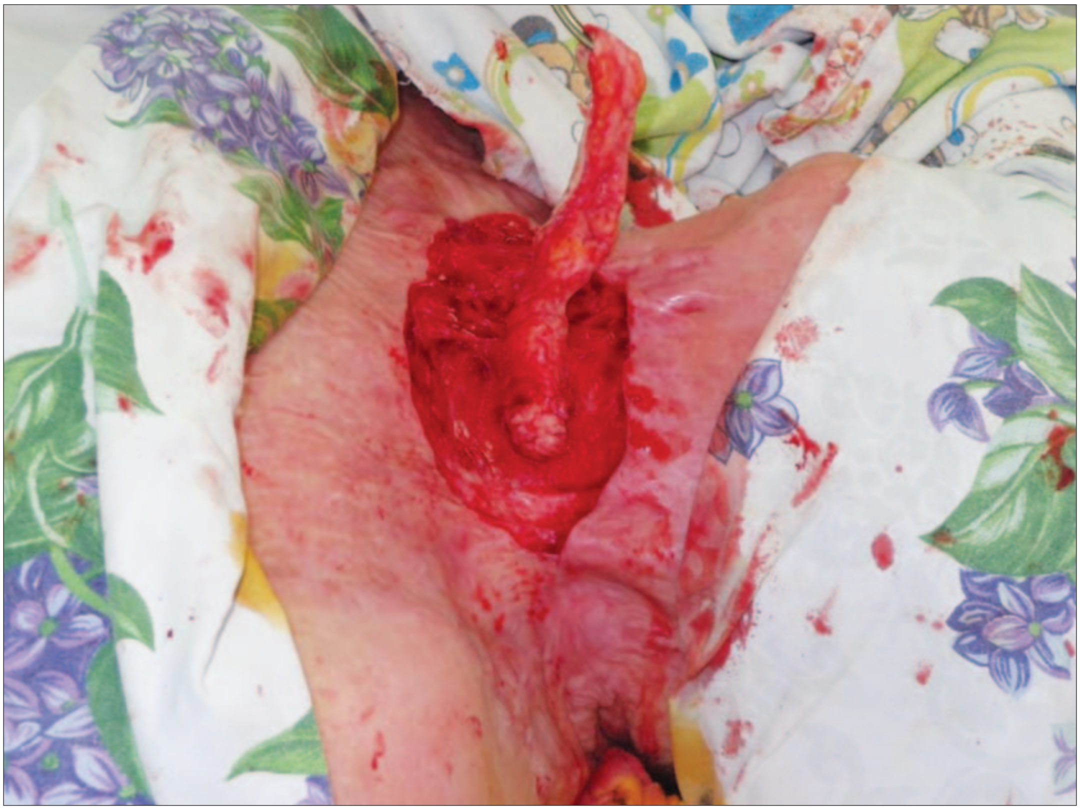


Figure 6.51. Scars are excised, contractures are removed.

Figure 6.52. The wound after the scar excision.

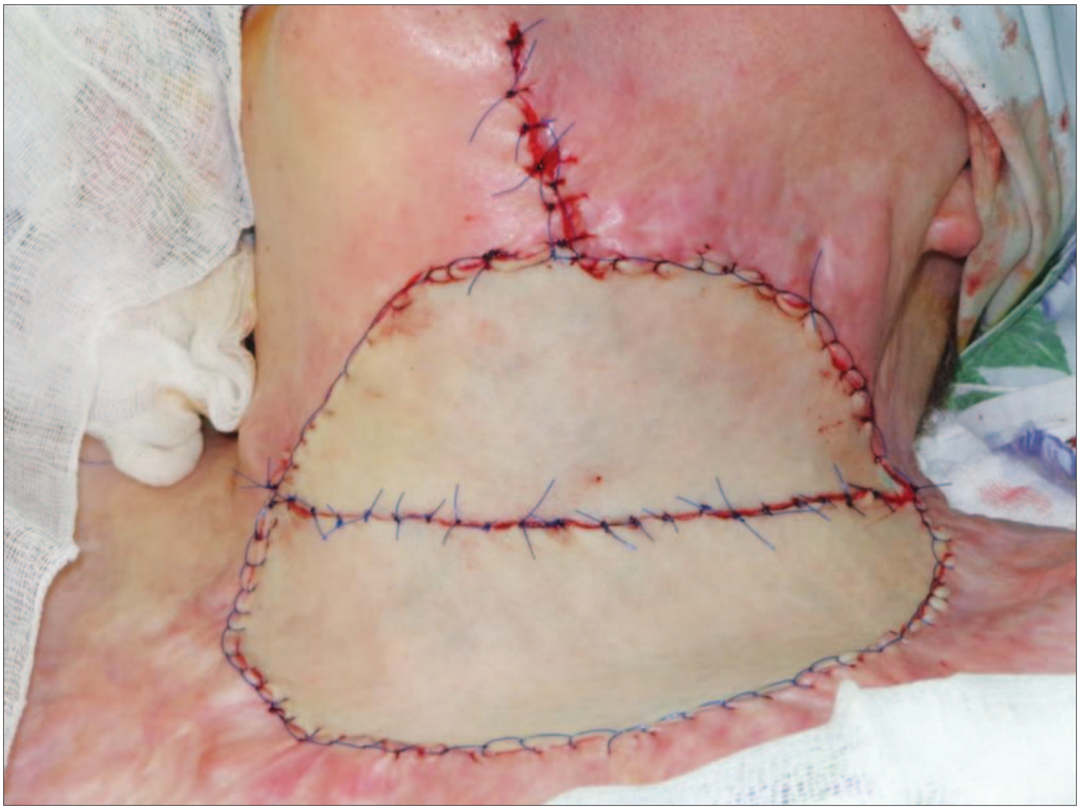


Figure 6.53. Free skin autoplasty using 0.9 mm thickness graft is performed.

Figure 6.54. Vacuum dressing is placed on the graft, which is also immobilization.

Figure 6.55. The first dressing change is carried out in 7 days.
The patient can move with the vacuum system and lie in any position.

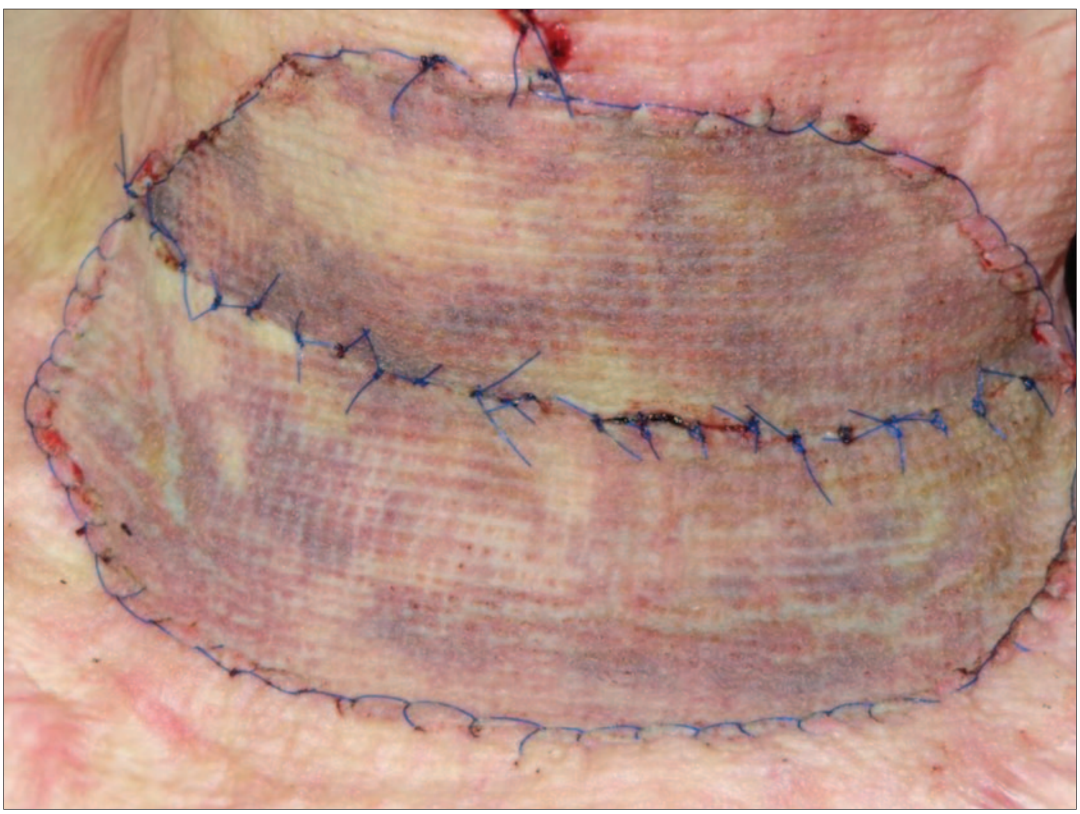


Figure 6.56. Complete adaptation of the graft is observed at the first dressing change.
The full-thickness graft has specific colour.

Figure 6.57. A year after staged surgical treatment in the neighboring region. The skin was epithelized for 1.5 months.

Figure 6.58. Hypertrophic scars in 8 years old child. Surgical treatment is indicated.

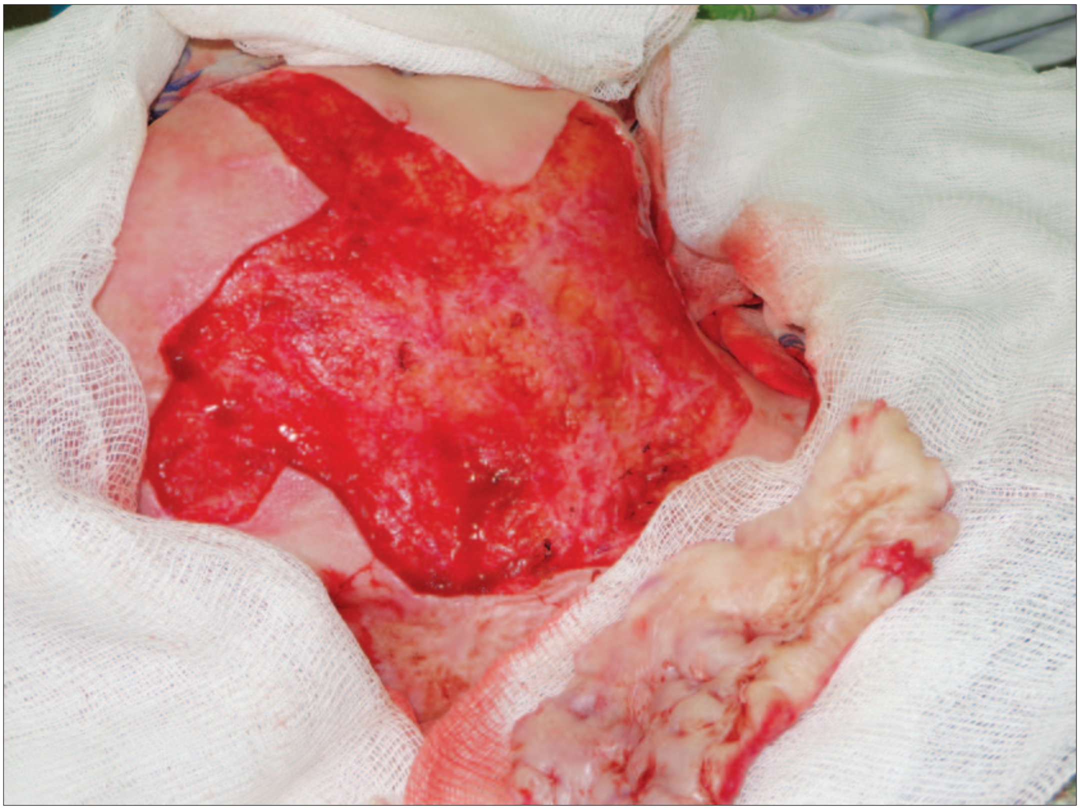


Figure 6.59. Scar block and linear scars are excised; the smooth wound bed is formed.

Figure 6.60. Autoplasty of the donor site using a split-thickness skin graft with a perforation 1:4 harvested nearby was performed.

Figure 6.61. Donor sites were covered by a meshed wound dressing.

Figure 6.62. Subcuticular suturing of linear wounds. The wound bed before autoplasty.

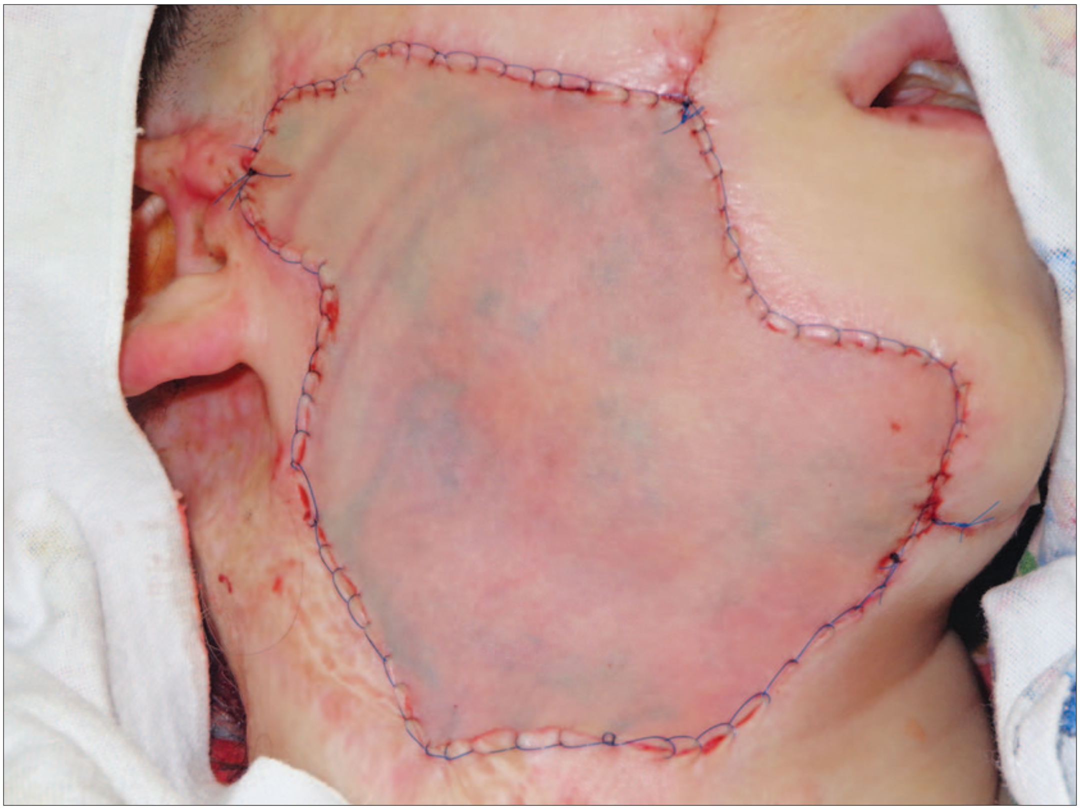


Figure 6.63. Plasty using a full-thickness graft and suturing according to the laws of plastic surgery: “dermis to dermis”, “epidermis to epidermis”.

Figure 6.64. “VoscoPran” with “Braunodin” is place before a sponge of the vacuum dressing.

Figure 6.65. The vacuum dressing is placed on plasty and subcuticular sutures.

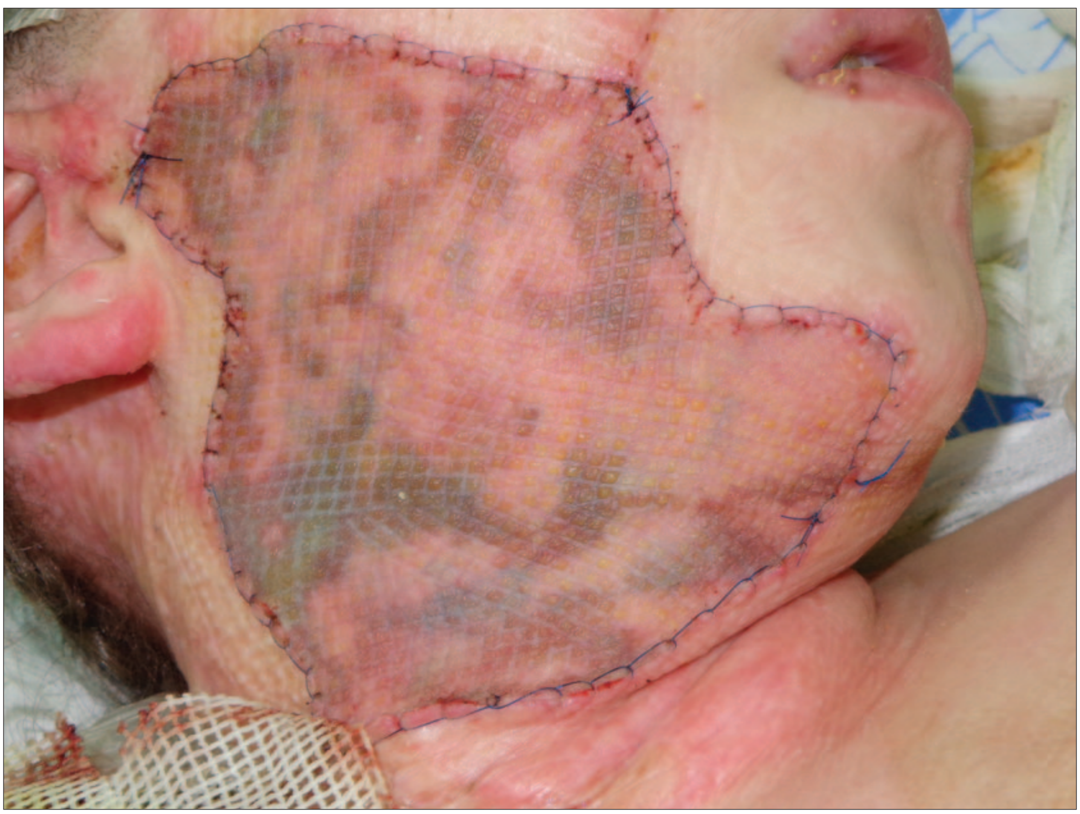


Figure 6.66. At the first dressing change in 5 days, complete snuggling of the graft is observed; the full-thickness graft has a specific colour associated with its engraftment.

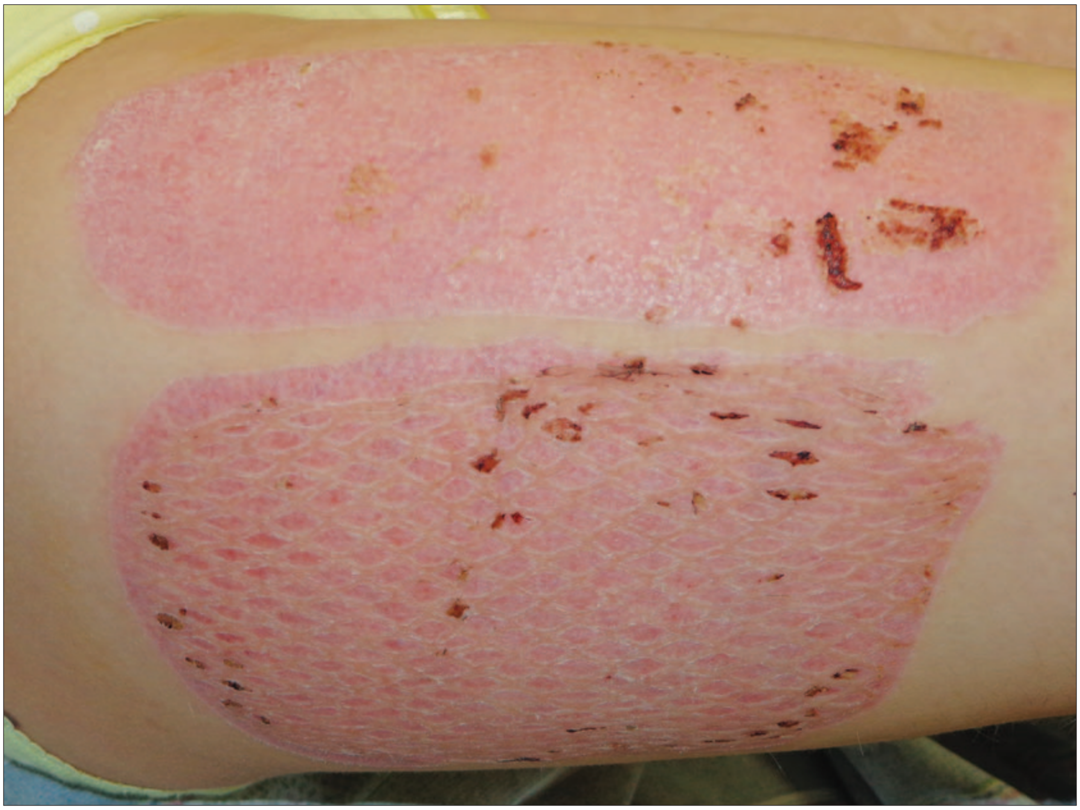


Figure 6.67. The donor size has epithelized in 19 days after the surgery.

Figure 6.68. Before discharge, on postoperative day 12. The graft has adapted, epidermal peeling of the full-thickness graft.

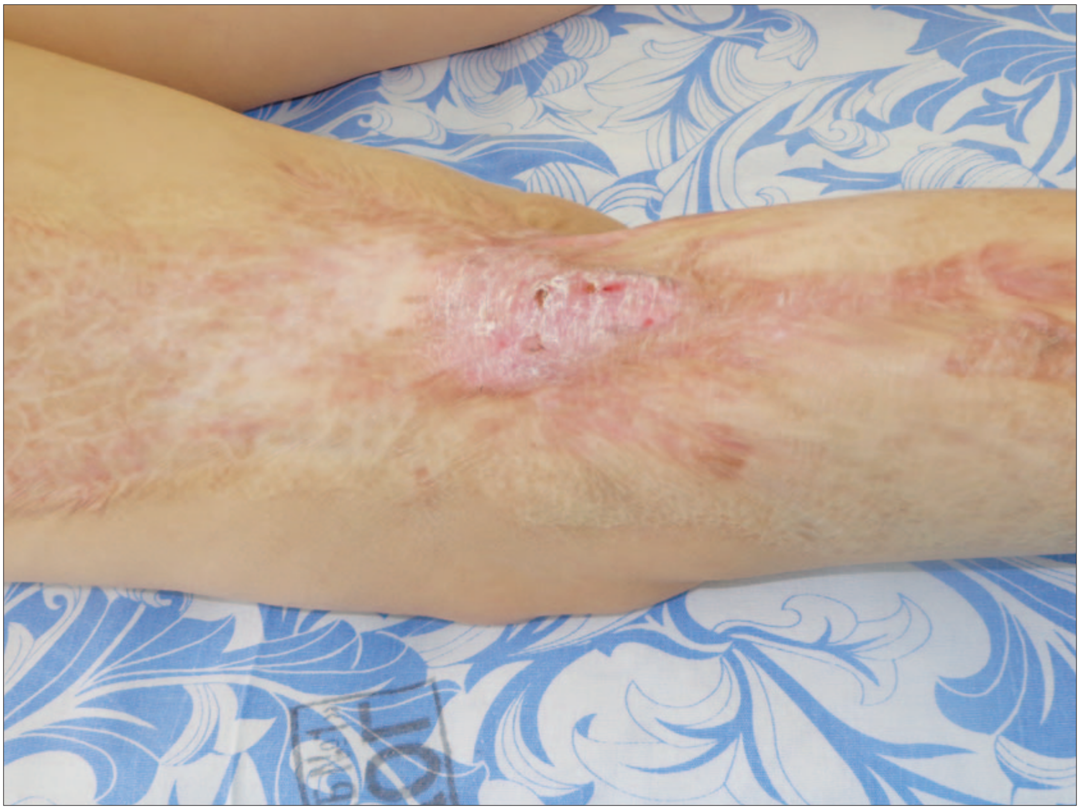


Figure 6.69. Post-burn scar contracture of the knee joint with ulceration.

Figure 6.70. Scars are excised; the contracture is removed forming Z-shaped contours.

Figure 6.71. Plasty using a full-thickness autograft harvested from the anterior surface of the body.

Figure 6.72. A vacuum dressing with constant pressure 100 mmHg is placed for 7 days. The patient wore the dressing without bending his knee.

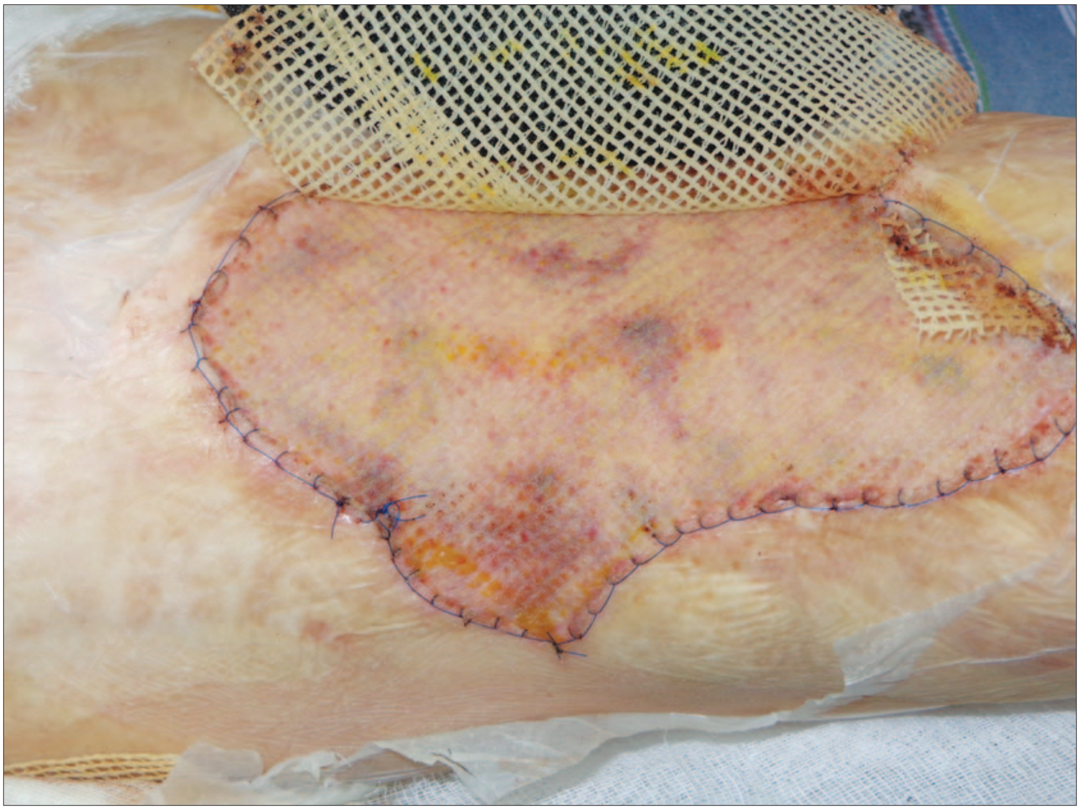


Figure 6.73. At the first dressing change, petechial hemorrhaging specific for a full-thickness skin graft is observed.

Figure 6.74. Epidermal peeling in 2 weeks. The full-thickness graft adapts more slowly than the split-thickness one.

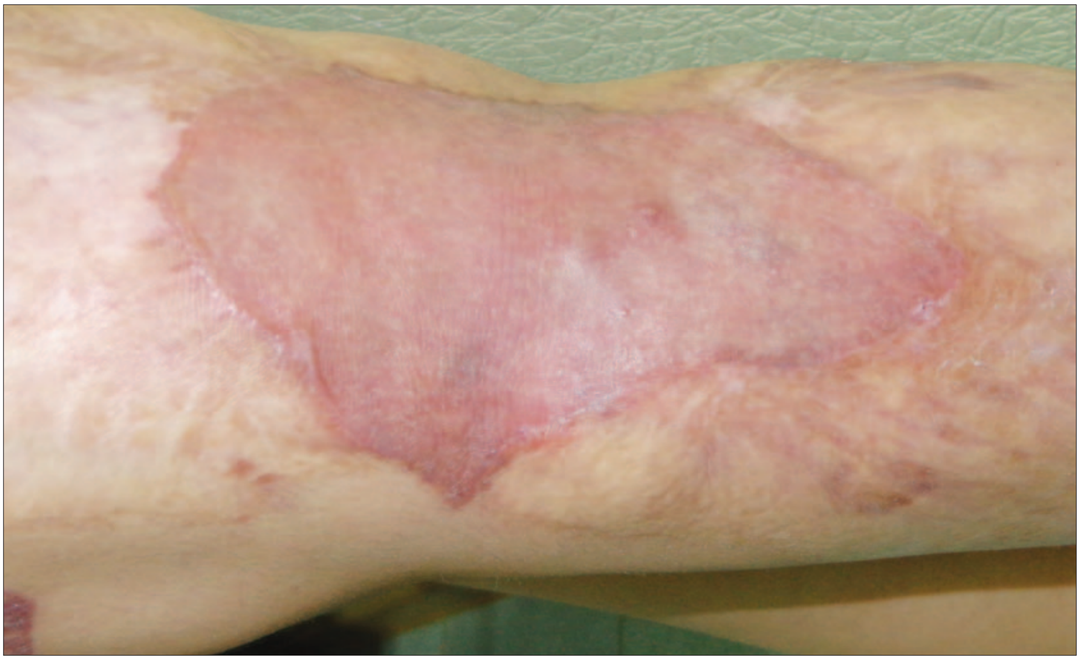


Figure 6.75. The full-thickness graft does not have the scar tissue in 3 months.

CHAPTER 7.
CELL THERAPY IN COMBUSTIOLOGY

7.1. Modern issues of cell therapy.

At present, the issue of skin recovery after deep and vast burns remains vital, even though the surgical approaches to treatment of patients with burns have been improved. Cadaver allograft (alloplasty is not used in Russia at the moment due to absence of legal base), heterograft and a wide range of synthetic materials are used by a combustiologist for temporary covering of wound surfaces after necrectomy. However, the specified methods cannot be used to recover skin integrity and they do not rule out traditional wound closing method with the help of autoplasty by means of split free skin grafts. Shortage of skin resources may take place in case of deep and vast burns. In these cases, use of cell therapy is feasible and justified. Cell therapy implies therapeutic infusion of living cells aimed at tissue regeneration, maintenance or recovery of the function (for example, wound healing) or modulation of pathophysiological processes (for example, inflammatory or immune responses). Since 2017, the term “biomedical cell product” aimed at delivery of cell therapy is introduced in our country.

The cell technologies development started back in the middle of the last century. Significant development of these methods took place in the 40-50s of the 20th century when Ross Granville Harrison, an American biologist, doctor and embryologist, described the living cell culture method in laboratory conditions in 1907-1910. For a long time, up to the middle of the 70s of the last century, fibroblasts were the only cells which were actively cultured and used in medicine as long as they could maintain diploid karyotype in vitro, they partially lose surface antigens of histocompatibility and they can be cultured for a long time.

At present, we can talk about experience obtained in generation and use of different cell types for closure of skin defects, such as keratinocytes, fibroblasts and mesenchymal stromal cells of different origin. However, generation of an appropriate tissue-engineered skin which could replace autoplasty by means of a mesh graft still remains an unsolved problem in national combustiology.

Use of cultured fibroblasts is one of the most promising directions of cell therapy for skin damage. Unlike epithelial cells (keratinocytes), culture of dermal fibroblasts does not require special conditions and has a relatively low prime cost. Use of cultured in vitro fibroblasts became widespread and was accorded recognition as a safe and efficient method as well as presented in many reviews. It is known that fibroblasts cultured by synthesis of extracellular matrix components stimulate keratinocyte adhesion, proliferation and differentiation as well as directly impact wound healing, initiate growth of the remaining epithelium foci as well as promote better acceptance of autodermal graft.

One of the differences of fibroblasts from keratinocytes is absence of immunological properties. This circumstance enables use of allogenic fibroblasts without immunosuppressive agents as well as setting up a bank of allogenic fibroblasts.

Use of dermal fibroblasts in Russia was first suggested by D.S. Sarkisov and members of A.V. Vishnevsky Institute of Surgery (Russian Academy of Medical Sciences) who presented a unique and efficient way for burn wound treatment with the use of cultured fibroblasts in 1993.

The results of national scientists determined development of cell technologies for burn wound treatment. Fibroblasts are obtained from skin biopsy sample by mechanical disaggregation or enzymatic treatment of skin samples. The enzymatic method of obtaining fibroblasts by collagenase solutions with or without tripsin has become most well-known. The cells are cultured in standard conditions to monolayer condition and after passing the cell culture will be built up to the required quantity. The process of obtaining the fibroblast culture takes 2.5 to 3 weeks, which makes relevant the process of setting up a bank of allogenic fibroblasts ready to use early after the patients get the burn wound and are indicated for cell cultures.

Use of fibroblasts as part of dermal equivalent when cells are used together with the carrier is the most promising way for skin defect management.

Presence of the carrier for the cultured cells during transplantation is viewed and discussed over the years. Back in 1980 Cuono C. and his colleagues reported that a substrate in the form of allogenic derma was required for proper acceptance of cultured autologous keratinocytes. A two-stage procedure is required to make the Cuono's method efficient. A skin allograft is used at the first stage for temporary closure of the wound bed. Autologous epithelial cells are cultured from a small skin biopsy sample in the course of two to three weeks. After that, autologous keratinocytes are used together with allogenic derma for final closure of the wound surface. This two-stage complex method (allograft / cultured cells) of transplantation became widespread and was used successfully in many centers in the end of 1990s. The main drawbacks of the suggested method are the following. Firstly, skin allografts are not readily available, secondly, if the cadaver skin separates before obtaining the cultured autologous keratinocytes, then it becomes impossible to use them with allogenic derma (based on Cuono's method) for further transplantation.

Further development of biology and engineering led to generation of many skin equivalents on different carriers and some of them became available at commercial market. Many of these products are at stages of pre-clinical and clinical researches.

Conditionally presented skin equivalents can be divided into dermal, epidermal and mixed types depending on the type of cells which are used in these products. Keratinocytes are used in epidermal equivalents as a cell component of the tissue-engineered structure. Dermal equivalents usually contain allogenic fibroblasts and full skin equivalents are represented by all types of cells (both keratinocytes and fibroblasts). All commercial skin equivalents can be divided into acellular and cell products. Acellular skin equivalents do not contain cells; they consist of different polymeric compounds. To some extent they simulate the basic features of extracellular matrix in the human derma by providing some kind of integrity and elasticity. However, these products have no epithelial layer and in most cases, use of such products is to be combined with transplantation of skin autograft in two stages.

Most popular are acellular grafts made of artificial biological materials, such as

Integra and MatriDerm. Grafts made of natural biological materials (such as AlloDerm and Permacol) usually represent decellularized skin of humans or animals (pigs). Such grafts have advantages as long as they have natural skin penetration for regeneration and vascularization and they maintain adhesion, growth and functions of many cell types.

So the efforts of using the combinations of carriers and cell cultures became quite regular. The first combined use was back in 1984 when Gallico G. and his co-authors described the use of allografts with further application of the epithelial keratinocyte culture to a patient with 97% of burn area. However, the problem of keratinocyte acceptance in the wound in absence of fibroblasts and high cost of these products limited their use.

At the moment, development of dermo-epidermal equivalents with both epidermal and dermal cells is the most vital question. The commercial products include skin equivalents with Apligraf (contains keratinocytes and fibroblasts), Dermagraft (fibroblasts), OrCel (fibroblasts and keratinocytes), etc. And all of them are expensive and not available at our market.

The future outlook of developing the autologous composite equivalents consisting of collagen and glycosaminoglycan substrate which contain autokeratinocytes and fibroblasts should be pointed out. Very recently a group of German scientists reported on generation of a tissue-engineered autograft on the basis of MatriDerm, seeded with autologous fibroblasts and keratinocytes which essentially comply with the human derma. However, the problem of the autologous technology use is that it takes time to culture the cells and generate a ready graft for grafting which may be absent in patients with vast burns.

Even though the cell technologies are well-known and used since long for treatment of skin wounds, today use of cell products on the basis of fibroblasts and/or keratinocytes is not regular and has really important limitations. And there are several reasons to this. One of the reasons is related to a long absence of regulatory documents in the Russian Federation. Besides, efficiency of cell therapy was proved in most of the works only indirectly, and it is not possible to extrapolate data received from laboratory animals on humans which leads to restriction in use of cell technologies. Suspicion of the clinicians and limitedness of public information form either a negative or a way too active attitude of the practitioners. In either case, scientific achievements in the area of cell technologies continue to develop and search of methods of their use is of considerable interest; it will also increase quality of administering medical aid to burn patients.

Figure 7.1. Fifth day after flame burn. Eschar generation on lower limbs.

Figure 7.2. Early tangential necrectomy up to derma sublayers is carried out under a tourniquet on the left lower limb.

Figure 7.3. Primary skin autoplasty is carried out with mesh autografts.

Figure 7.4. Burns with subfascial injury on the left lower limb.
Nectrotomy is carried out on the first day.

Figure 7.5. Adipose tissue and skin sampling from uninjured areas is carried out during this surgery for mesenchymal stromal cell culture.

Figure 7.6. Fascial necrectomy is carried out on the left lower limb up to vitalized tissues.

Figure 7.7. The plasty adapts on the left lower limb. The granulation tissue is generated on the right one in two weeks (19th day after the injury).

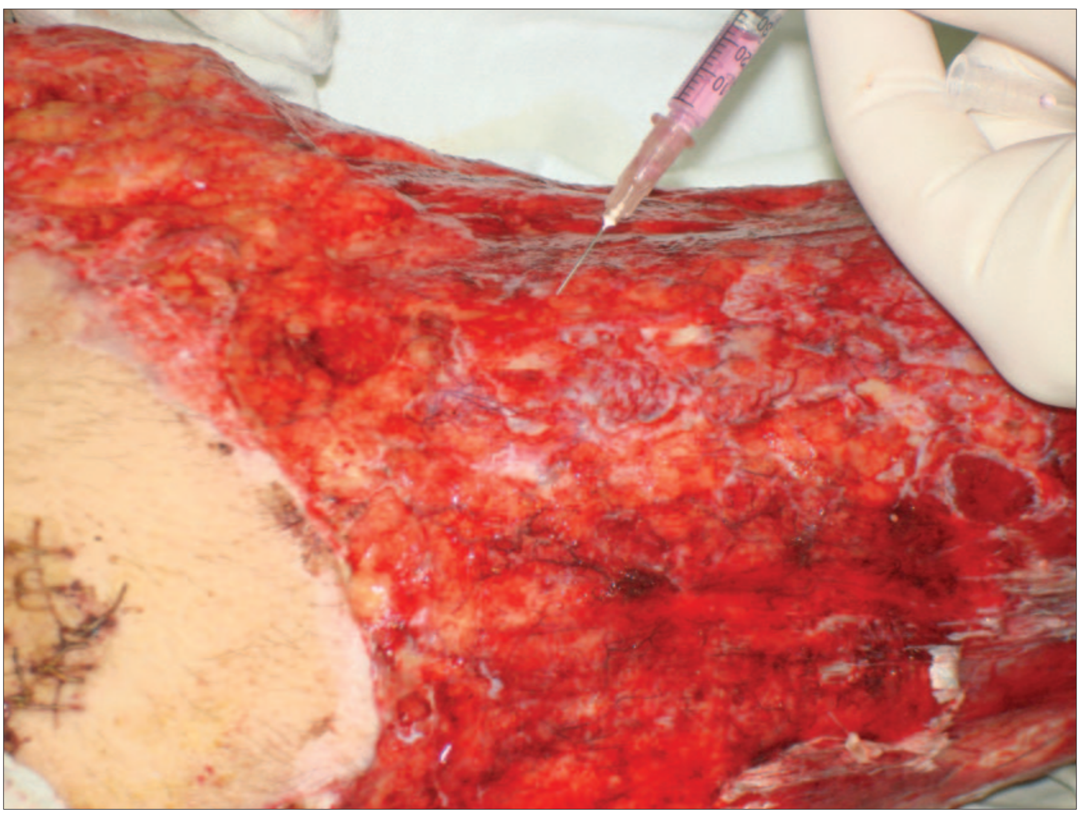


Figure 7.8. The wounds of the left lower limb are injected and watered with mesenchymal stromal cells cultured in the laboratory.

Figure 7.9. Skin autoplasty is carried out with mesh autografts.

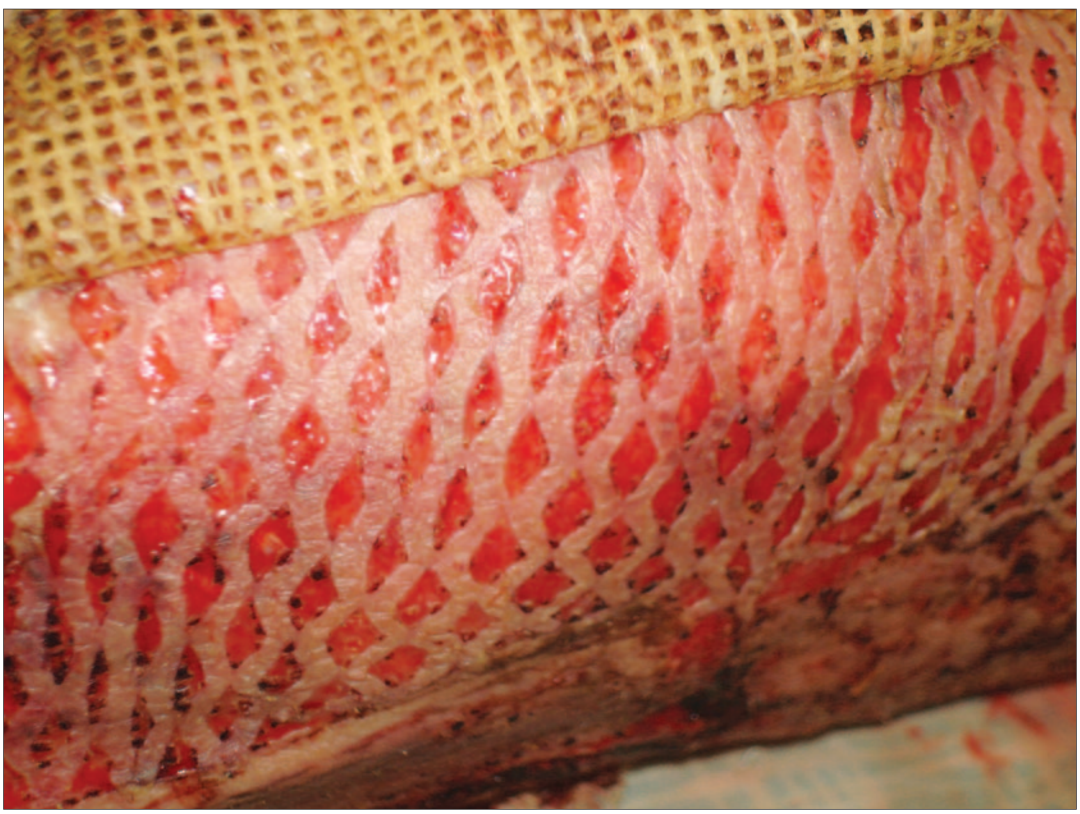


Figure 7.10. Cell-like epithelialization is observed during the first dressing on the fourth day after the surgery.

Figure 7.11. No scar tissue is observed on the left lower limb (unlike the right limb) in three months after the injury due to use of mesenchymal stromal cells.

7.2. Auto- and allofibroblasts in combustiology.

Individual clinical researches per protocol of autologous fibroblast use in treatment of burn wounds for scientific purposes are carried out in SBIPH 'Scientific Research Institute – S.V.Ochapovsky Regional Clinic Hospital No 1' of Ministry of Health of Krasnodar Region since 2017.

Clinical case. Patient O., male, 70 years old, was admitted to the intensive care unit of the burn center in two days after the injury from the CDH with II-III degree heat (flame) burn of the face, body and limbs 31%. Severe thermal inhalation injury. Burn disease at the stage of acute toxemia. The disease was complicated by a severe undulant burn sepsis and bilateral multisegmental pneumonia (Figures 3.12 and 3.13).

The patient underwent a surgery which included step-wise necrectomy and amputation of the right upper limb at the level of the right shoulder middle third.

Considering that the patient had a severe burn with injury of upper limbs and body, burn disease and grave condition which required connection to an artificial respiratory unit through tracheostoma, the patient was included into the clinical research protocol.

In order to obtain the autologous fibroblast culture, the skin autograft sampling was carried out on the right thigh (0.3 mm thick and with area of 20 cm2) on the first operating day with the use of electric dermatome ДЭ-60. The sampling was carried out in sterile conditions under general anesthesia. An aseptic dressing was applied on the donor site after carrying out the sampling. The skin graft was transported in a sterile tube on a transport medium to the laboratory with further cell isolation and culture.

In 26 days the autologous fibroblasts seeded on a polymer carrier were cultured. Researches proving the culture quality were carried out. These researches included the following: cell count, morphological analysis, bacteriological control, karyotyping and immunophenotyping. The autologous fibroblast culture on a substrate was prepared and transported to the operating room for autoplasty on the operating day. The skin autograft sampling (0.3 mm thick and with area of 1200 cm2) was carried out on both thighs under anesthesia with the use of electric dermatome DE-60 (Figure 7.14). Fibrino-nectrotic pellicle was removed from the wounds as well as hypergranulations from the wounds of the right shoulder stump. After hemostasis, skin grafts were meshed 1:4 (Figure 7.15), cut along the edge of the right shoulder stump (2% of the body surface) and body (13% of the body surface) wounds and applied on the wound surfaces at 15% of the body surface. The cultured autologous fibroblasts on a substrate are grafted in the cells of skin grafts. Gauze bandages are applied on the top and the wounds are covered with aseptic dressings (Figures 3.16 to 3.19).

In four days after the scheduled change of dressings, generation of epithelial tissue in the place of carried out autoplasty was noticed (Figure 7.20). On the sixth day after the surgery, complete epithelization of burn wounds is reported (Figure 7.21).

Figure 7.12. Third day after a severe burn wound

Figure 7.13. Amputation of the right upper limb is shown. Necrotomy cuts are made on the first day

Figure 7.14. Taking split skin autografts 0.3 mm thick.

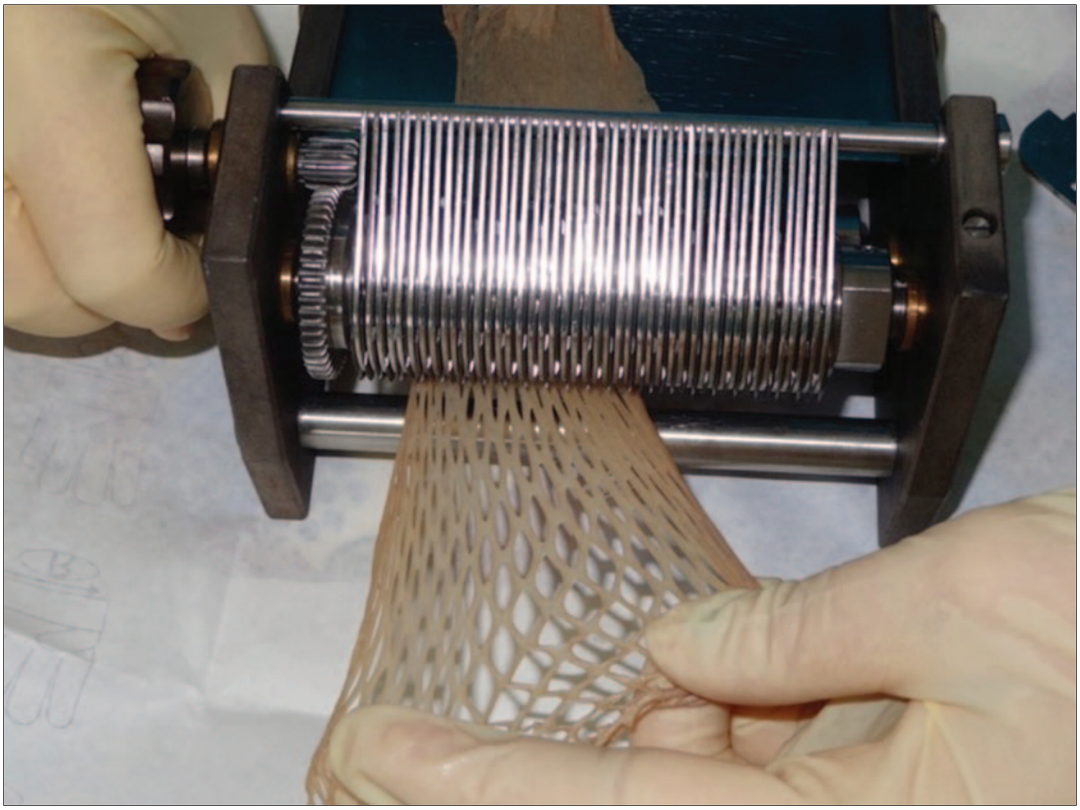


Figure 7.15. Meshing of autodermografts

Figure 7.16. The patient is very ill in three weeks (artificial pulmonary ventilation, sepsis, pneumonia and thermal inhalation injury); granulation tissue has generated.

Figure 7.17. Skin autodermoplasty is performed with a perforation index1:4.

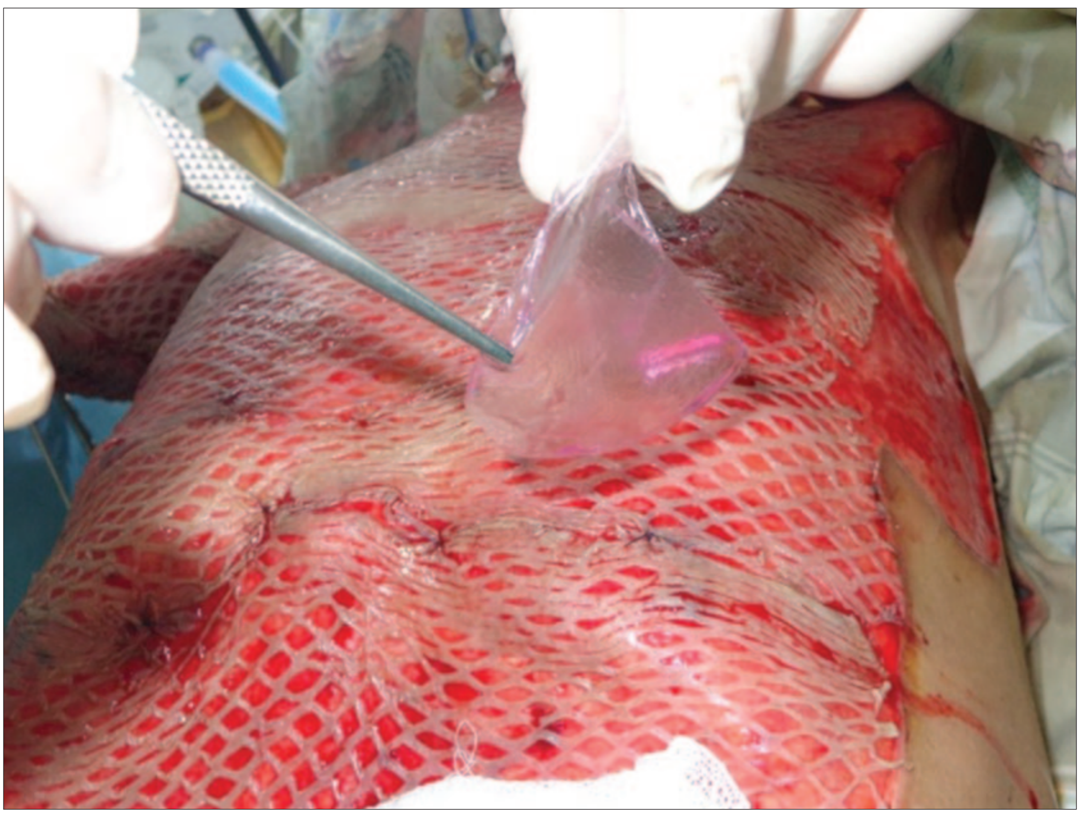


Figure 7.18. Cultured autologous fibroblasts on a substrate are grafted on autoplasty.

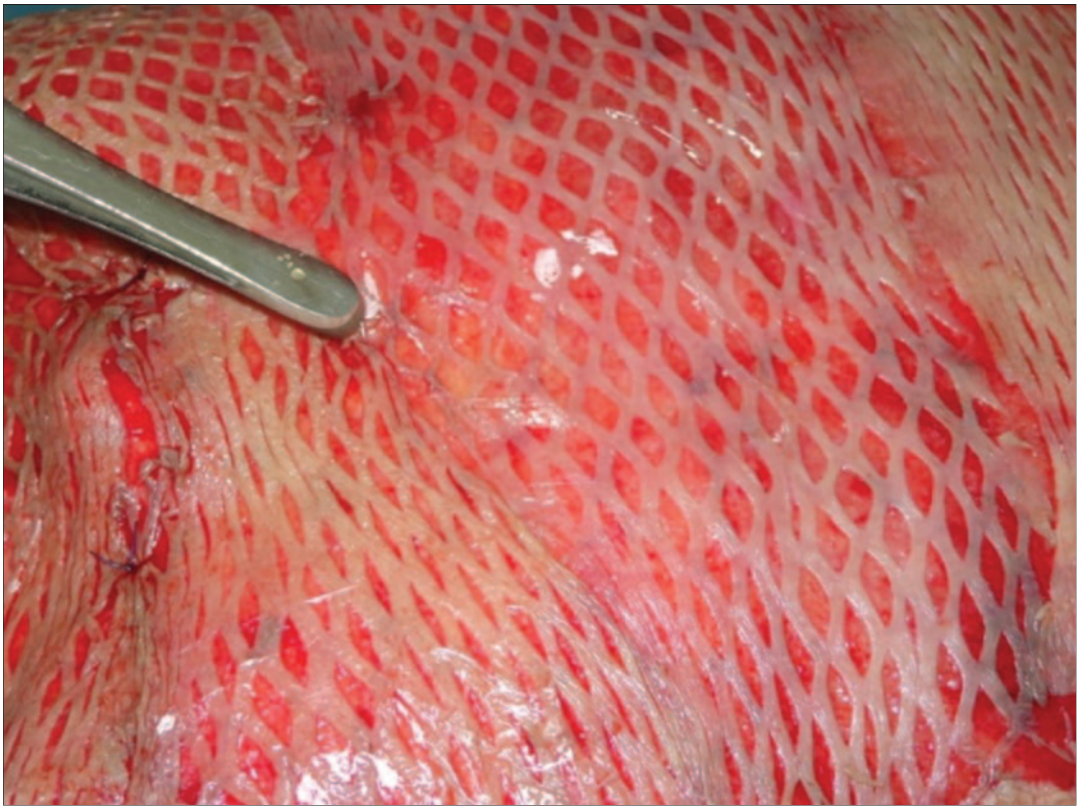


Figure 7.19. The wounds are watered by autologous fibroblasts and in solution.

Figure 7.20. Despite a very grave condition, due to use of autologous fibroblasts, cell-like epithelization is observed on the fourth day.

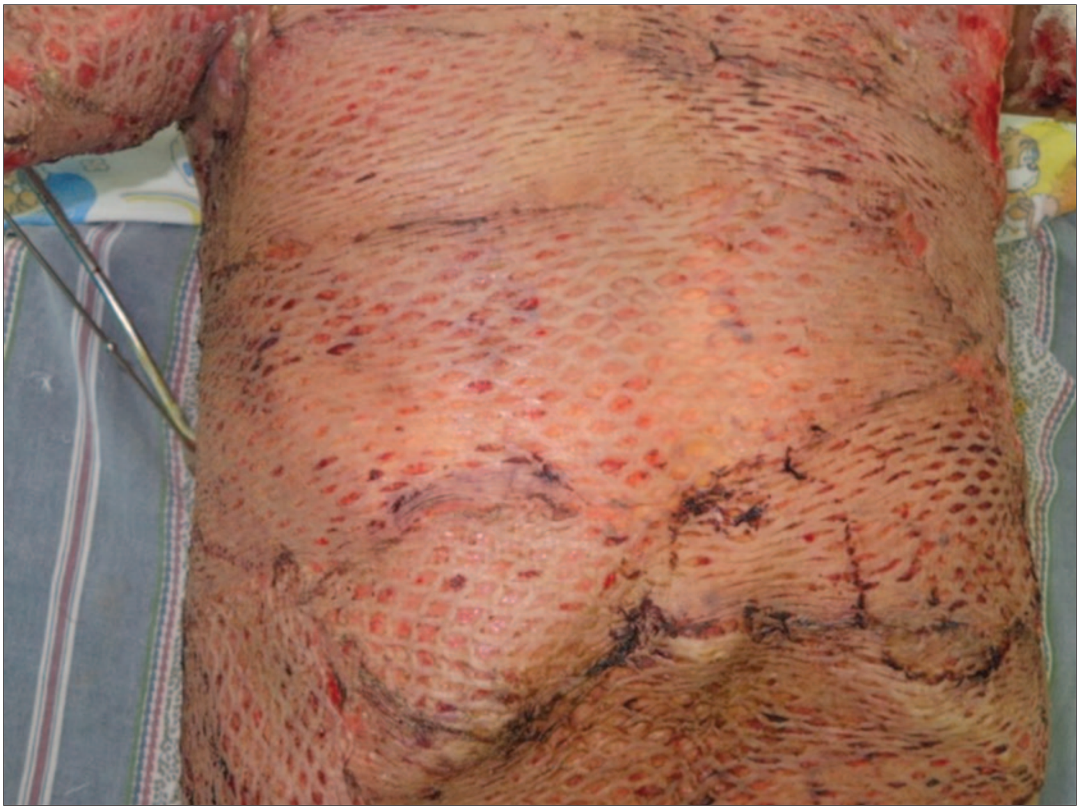


Figure 7.21. Complete graft adaptation and cell-like epithelization on the sixth day after the surgery.

7.3. New types of skin autoplasty with combined allo- and autofibroblasts.

New methods of operative therapy for burn patients are developed by us in order to improve use of dermal fibroblasts.

The first method allows improving MEEK technology. The tasks are to: improve the method of treating the deep skin damages; improve the method of MEEK meshing; improve and speed up acceptance and epithelization of the split mesh autograft; decrease the area of donor sites using the MEEK meshing and autologous fibroblasts; learn the potential of the MEEK meshing fabric for dermal fibroblast adhesion; solve the issues of donor resource shortage in severe burnt patients.

The method implies the following: in the first 1-3 days after the injury, split skin autograft (0.25 to 0.3 mm thick and with area of 5 cm2) is taken for obtaining the dermal autologous fibroblast culture of the fourth subculture. Then in NaCl normal saline solution (0.9%) in the final concentration of 2.0 million cells in 1 ml, at consumption rate of minimum 40 thousand cells per 1 cm2 of the wound surface and mesh autograft, during the surgery and prior to autoplasty they will water the wound, dermal surface of the mesh skin pieces and the MEEK meshing fabric which can adhere dermal fibroblasts.

Technical result: the method allows creating conditions for fast acceleration and epithelization of the mesh autograft due to use of autologous fibroblasts. Use of autologous cells eliminates the risk of transmitting transfusion-transmitted infections. The studied property of the MEEK meshing fabric to adhere up to 2/3 of dermal fibroblasts in NaCl solution (0.9%) during watering, allows improving the engineering aspects of fibroblast use during autoplasty by means of their even distribution. Carrying out autoplasty and MEEK meshing together with autologous fibroblasts allow to decrease the area of donor sites. This will solve the issue of donor site shortage in severely burnt patients, hence increasing the quality of treatment.

Clinical case. Patient B, 65 years old, was admitted to the burns depertment of the S.V.Ochapovsky Regional Clinic Hospital No with the following diagnosis: 3-4 degree heat (flame) burn of the body and lower limbs 31%. The main stages of treatment and plasty by split skin graft with MEEK meshing with use of autologous fibroblasts are shown in Figures 3.22 to 3.27. The patient was admitted on the second day after the injury from the region. A deep burn with a generated eschar was observed. On the second day after the injury a free split skin autograft (0.25 to 0.3 mm thick and with area of 5 cm2) was taken from the right shoulder front surface by electric dermatome DE-60 in the operating room and sent to the laboratory for obtaining a dermal fibroblast culture. For fibroblast isolation, skin biopsy sample is milled by a scalpel and incubated with enzymes (collagenase solution 0.2% and trypsin solution 0.25%) for 24 hours at 4°C. After treatment with enzymes, epidermis is separated from derma and placed in a culture flask (area of 25 cm2). Then a culture medium which consists of a DMEM solution with a 10% autoserum is added and it's cultured to a monolayer condition generated by fibroblasts. Further culture is carried out in a DMEM solution with a 10% autoserum till fourth subculture to obtain the required amount. On the operating day, the cells are taken from flasks, washed from the culture medium and resuspended in the final concentration of 2.0 million cells in 1 ml, at consumption rate of minimum 40 thousand cells per 1 cm2 of the wound surface and autograft. When studying the property of the MEEK meshing fabric, its ability to adhere up to 2/3 of fibroblasts in NaCl solution (0.9%) during watering was found out. The total duration of obtaining a fibroblast culture lasts 25 days.

The patient received intensive general and topical treatment which included necrectomy and wound preparation for autoplasty. In 27 days after the injury, when granulation tissue was generated on thighs, the patient was taken to the operating room. Under general anesthesia (artificial pulmonary ventilation) a split autograft (0.3 mm thick and with area of 300 cm2) was taken from the left thigh back surface after standard treatment of the surgical field with electric dermatome. The autograft is meshed according to MEEK technology with ratio 1:3 (Figures 3.22 and 3.23) (application and distribution of autodermografts on a cork carrier in a form of a 5x5 cm square; incision of autodermograft on a skin perforator with a pneumatic drive; application of fibroglue in the form of a spray on autodermografts; shift of the autodermograft from the cork carriers on the fabric which is part of the set, removal of the carrier and elongation of the fabric). Then the fabric from the mesh piece side, the pieces from the dermal side and the wound are watered with an autologous fibroblast suspension (Figures 3.24 and 3.25). Autoplasty is performed (Figure 7.26). Operating time is one hour. Bandages are applied. In three days after the surgery, epithelization starts; complete epithelization and fabric removal take place on the seventh day of the surgery. The epithelization speed is same when using mesh grafts with ratio 1:2 and 1:3 but as per MEEK technology (Figure 7.27).

Figure 7.22. Application and distribution of autodermograft on a cork carrier in the form of a 5x5 cm square.

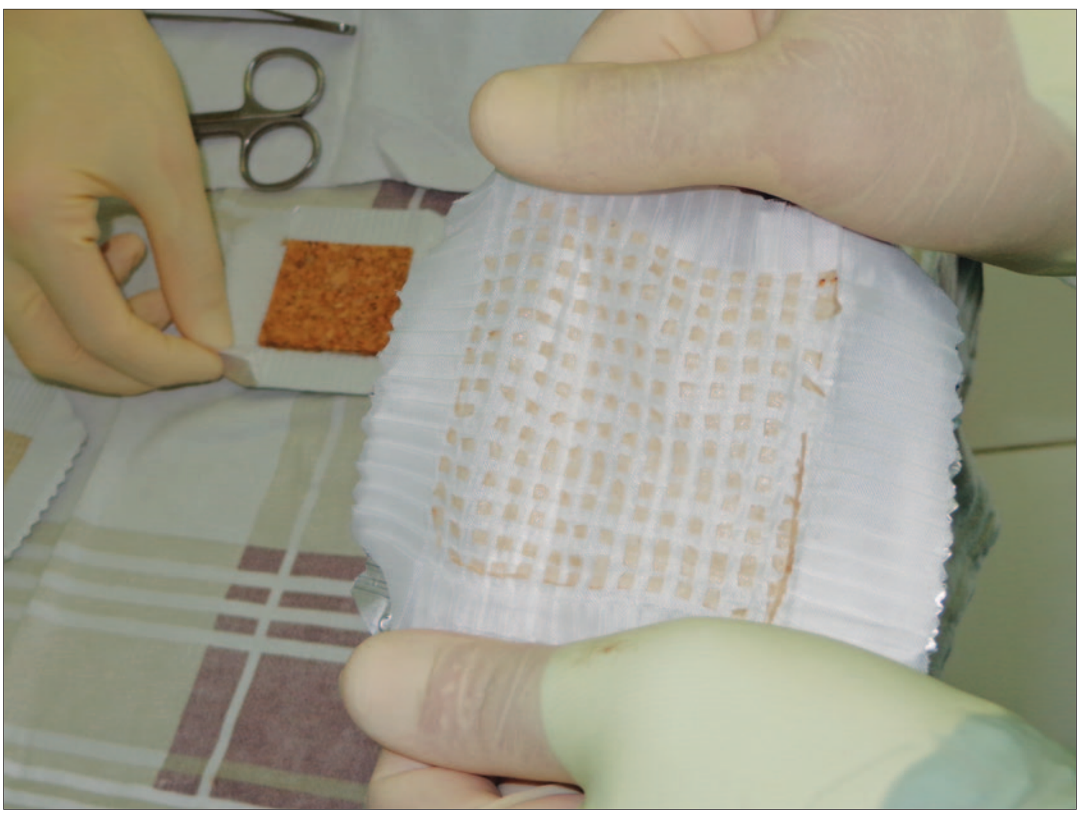


Figure 7.23. Elongation of mesh grafts with ratio 1:3 on a fabric carrier

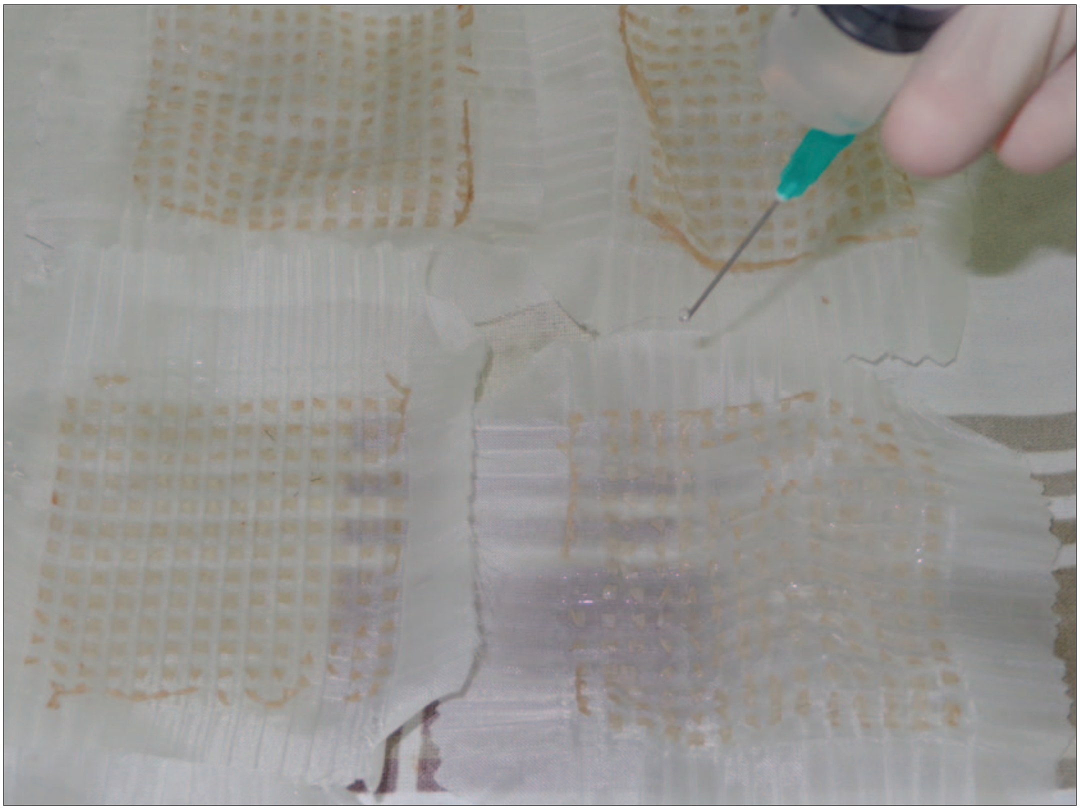


Figure 7.24. Watering of mesh grafts with autologous fibroblasts.

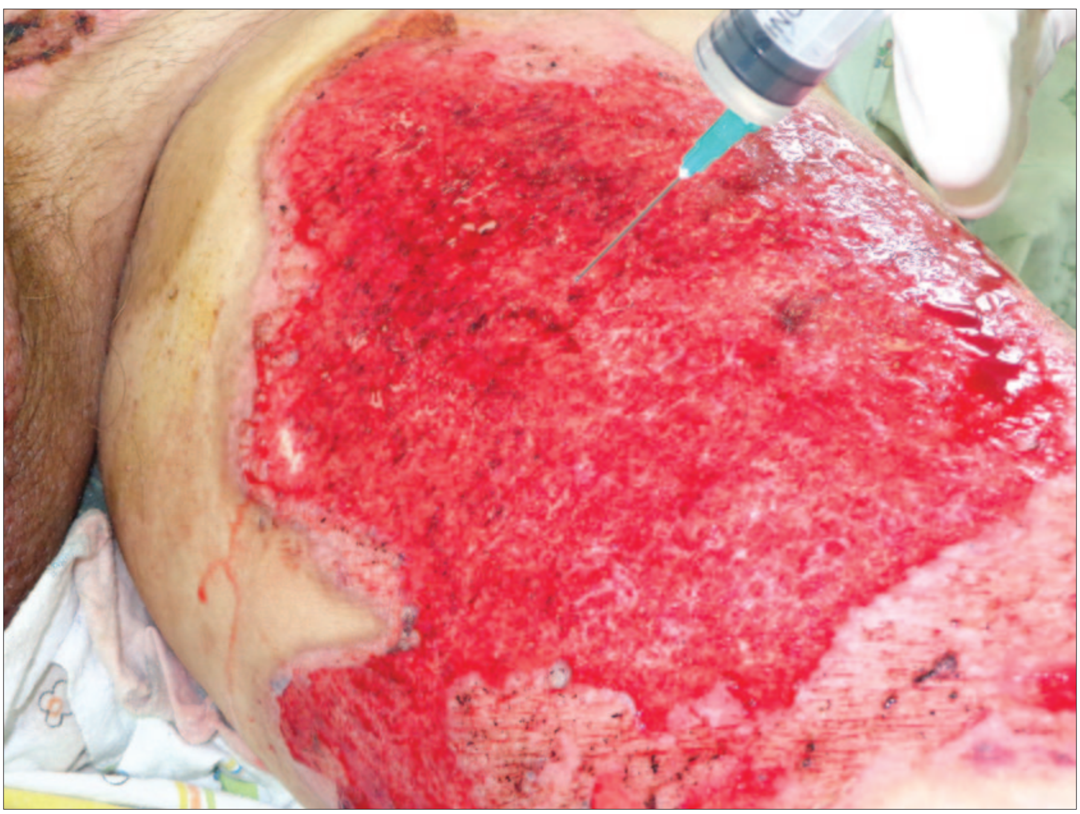


Figure 7.25. Application of autologous fibroblasts in a solution on the wound.

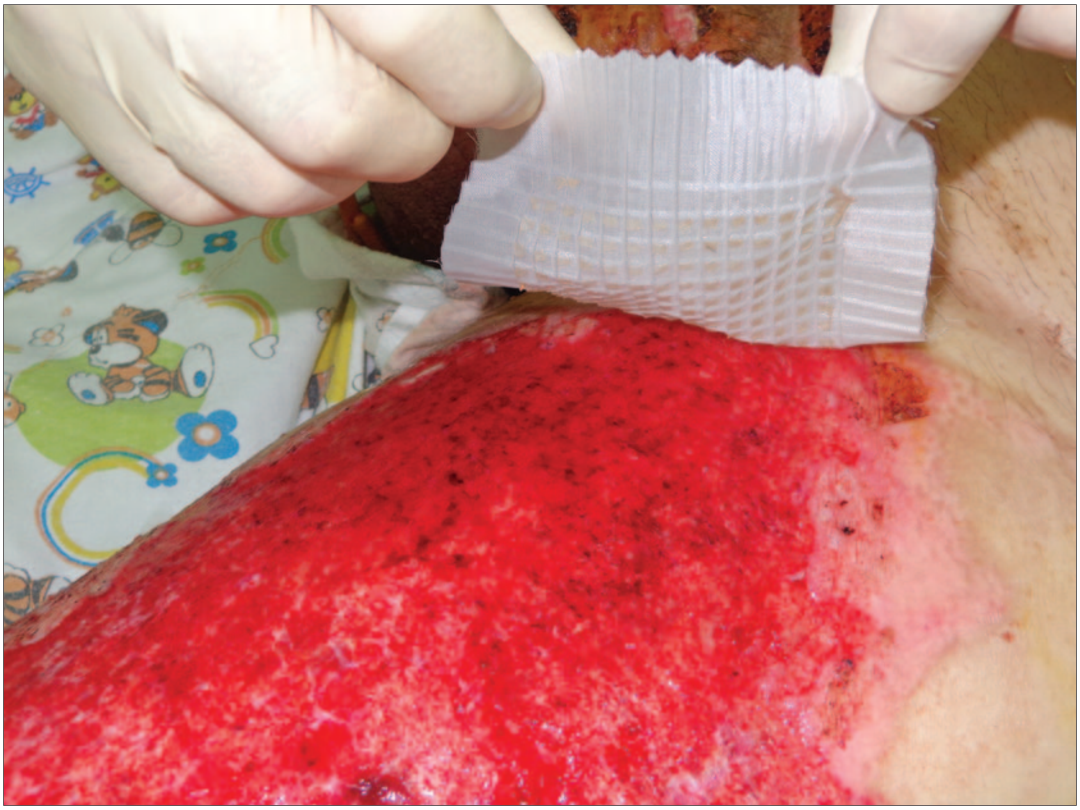


Figure 7.26. Plasty as per MEEK technology.

Figure 7.27. Adaptation and cell-like epithelization in seven days after the surgery.

The second method allows creating optimal conditions for acceptance of a full-thickness autograft. The tasks are to: improve the method of treating the deep skin damages; improve and speed up acceptance and epithelization of the full-thickness skin autograft; improve the cosmetic results during post-operative period by decreasing scar formation due to use of autologous fibroblasts.

The method implies the following: in the first 1-3 days after the injury, split skin autograft (0.25 to 0.3 mm thick and with area of 10 cm2) is taken for obtaining the dermal autologous fibroblast culture of the third subculture. Then in NaCl normal saline solution (0.9%) in the final concentration of 1.3 million cells in 1 ml, at consumption rate of minimum 25 thousand cells per 1 cm2 of the wound surface and autograft, during the surgery and prior to autoplasty they are applied on the full-thickness autograft internal surface and on the granulating wound lower layer for 25 to 30 minutes.

Technical result: the method allows creating conditions for fast acceleration and adaptation of the whole full-thickness free skin autograft on the granulating wound after its ablation due to use of autologous fibroblasts. Use of autologous cells eliminates the risk of transmitting transfusion-transmitted infections. Carrying out autoplasty with whole full-thickness skin autograft allows decreasing the risk of coarse scar tissue formation in a long-term post-operative period.

Clinical case. Patient D, 14 years old, was admitted to the burn deoartment of the S.V.Ochapovsky Regional Clinic Hospital No 1with the following diagnosis: 3-4 degree heat (flame) burn of the face, neck, body and upper limbs 31%. Burn of upper air passages. The main stages of treatment and plasty by whole full-thickness free skin autograft with use of autologous fibroblasts are shown in Figures 3.28 to 3.43. The patient was admitted on the second day after the injury from the region. A deep burn of the face, body and limbs with generation of an eschar was observed (Figure 7.28). On the second day after the injury a free split skin autograft (0.25 mm thick and with area of 10 cm2) was taken from the right thigh front surface by electric dermatome DE-60 in the operating room and sent to the laboratory for obtaining a dermal fibroblast culture. For fibroblast isolation, skin biopsy sample is milled up to 2x3 mm and incubated with enzymes (collagenase solution 0.15% and trypsin solution 0.25%). After treatment with enzymes, derma in a culture medium which consists of a DMEM solution with a 10% autoserum, is placed in a culture flask (area of 25 cm2) till generation of a monolayer condition by fibroblasts which migrated from the biopsy sample. Further culture is carried out in a DMEM solution with a 10% autoserum to the third subculture in order to obtain the required amount. On the operating day, the cells are taken from flasks, washed from the culture medium and resuspended in the final concentration of 1.3 million cells in 1 ml, at consumption rate of minimum 25 thousand cells per 1 cm2 of the wound surface and autograft. The total duration of obtaining a fibroblast culture lasts 22 days.

In 24 days after the injury under general anesthesia (artificial pulmonary ventilation) a 25x22 cm wound is observed on the face (Figure 7.29). The upper layers of granulations are dissected with a scalpel and dermatome. A wound is formed with granulation lower layers without exposure of subcutaneous fat. At a distance of 0.5 to 1.0 cm from the granulations and around the mouth cavity, nasal passages and eyes, a bounding cut is made with a scalpel. The wound edges as well as edge epithelization are cut from inside the wound to a healthy skin (Figure 7.37). Hemostasis. A whole full-thickness free skin autograft (25x22 cm) is taken from the abdomen front surface. Hypoderm is removed from a full-thickness autograft with scissors and dermatome (Figure 7.31). The edges of the abdomen donor site are repaired with an encircling stitch and autoplasty is carried out with a split autograft with mesh ratio 1:4 (Figure 7.30). A vacuum dressing is applied for adaptation and fast epithelization (Figures 3.32, 3.33 and 3.36). An autologous fibroblast suspension is watered on the full-thickness autograft internal surface for 25 minutes (Figures 3.34, 3.35, 3.38 and 3.39). Then an autoplasty is carried out with a full-thickness autograft on the face. For the surgery stages, see Figures 3.40 and 3.41. Operating time is 5.5 hours. Tile bandages, compressive bandages are applied. In six days after the surgery, a complete adaptation of the full-thickness skin autograft on the skin and of the split skin autograft on a donor site are observed (Figures 3.42 and 3.43). After a year of observation, a scar tissue in the area of plasty with a full-thickness autograft together with autologous fibroblasts is not formed.

Figure 7.28. Fifth day after a deep flame burn, an eschar is generated.

Figure 7.29. Generation of a granulation tissue in three weeks.

Figure 7.30. A full-thickness skin autograft is taken on the abdomen and autoplasty is carried out with a split graft on a donor site.

Figure 7.31. Subcutaneous fat is removed from a full-thickness graft.

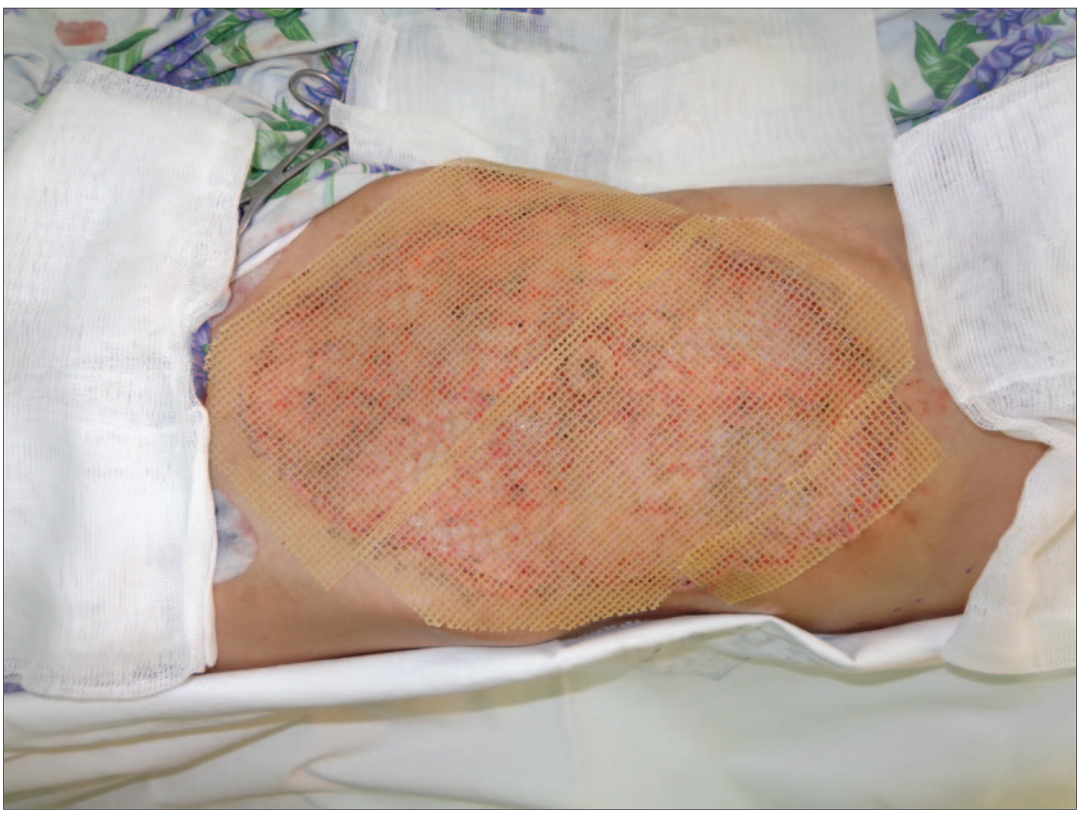


Figure 7.32. Mesh wound dressings are applied on the donor site.

Figure 7.33. Stages of applying a vacuum bandage.

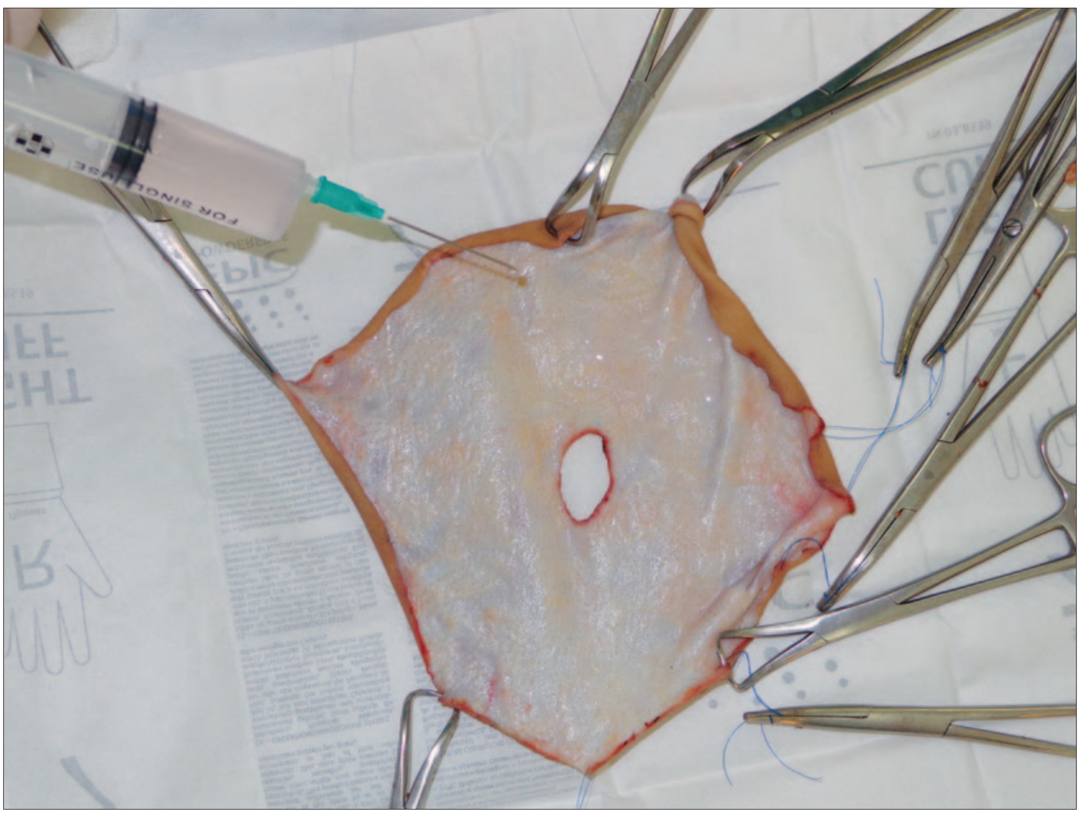


Figure 7.34. Watering a full-thickness graft from the derma side with autologous fibroblasts in a solution.

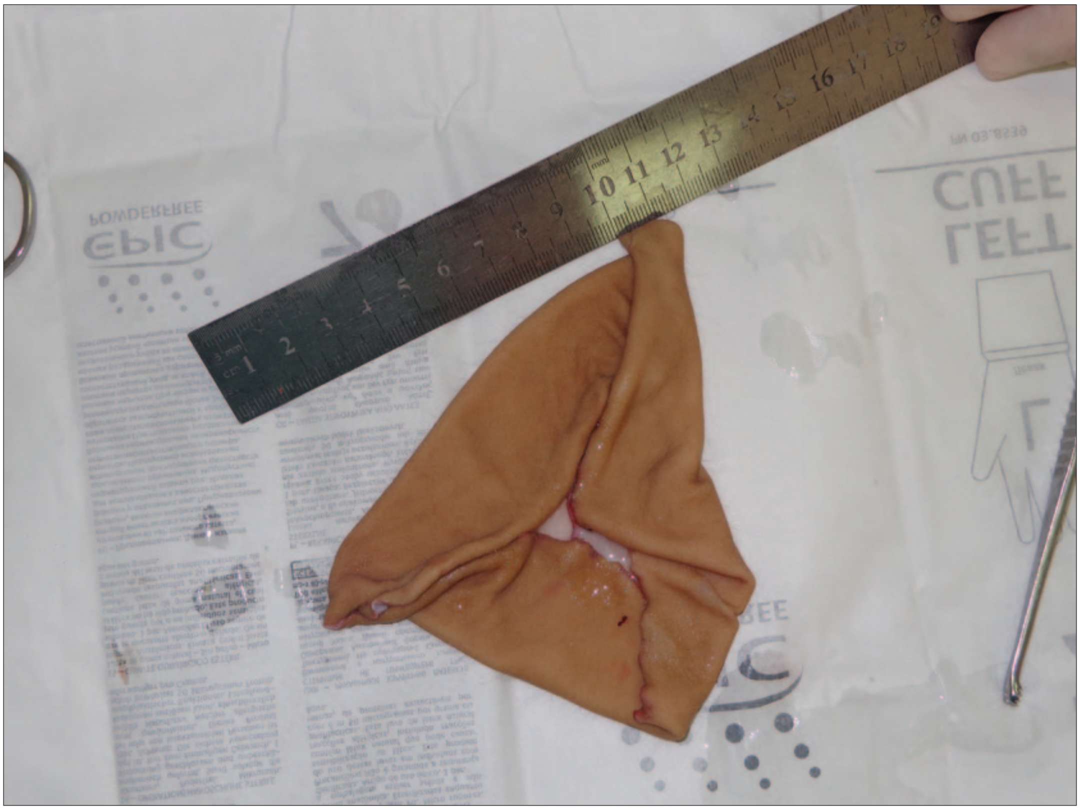


Figure 7.35. A full-thickness graft is wrapped for 25 minutes.

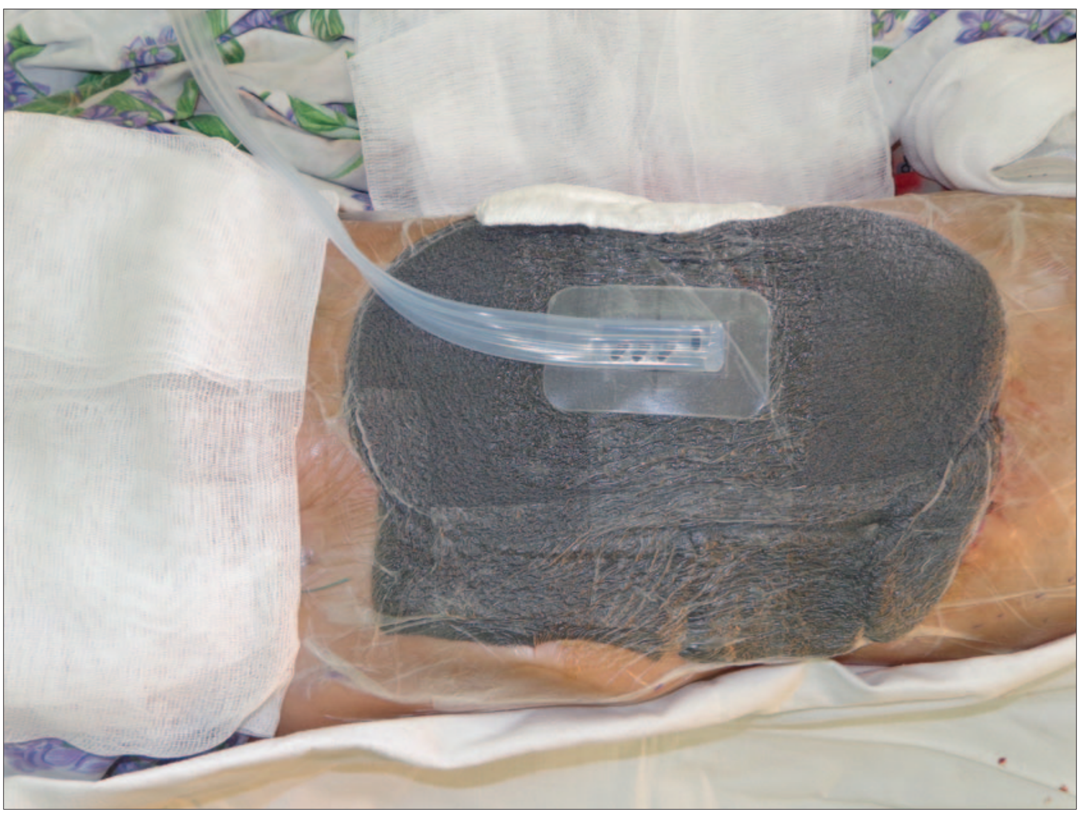


Figure 7.36. Vacuum therapy on a donor site with continuous pressure for six days.

Figure 7.37. The granulation tissue upper layers are dissected to fibrous layer and wound edge.

Figure 7.38. Watering the face wound surface with autologous fibroblasts for 25 minutes before plasty with a full-thickness graft.

Figure 7.39. A typical shining appearance of the wound after watering with autologous fibroblasts.

Figure 7.40. Face dermoplasty with one full-thickness autograft.

Figure 7.41. Appearance of the patient after the surgery.

Figure 7.42. On the sixth day after the surgery, the first dressing is applied on the abdomen, vacuum bandage is removed.

Figure 7.43. In eleven days a fast adaptation of the full-thickness skin autograft.

The presented clinical cases have shown efficiency of autologous fibroblasts in treatment of burn wounds.

The methods of treatment including a combination of autodermoplasty and autologous fibroblasts allowed creating conditions of fast acceptance and epithelization of the mesh autografts.

Summing up the abovementioned, we can conclude that there is no single method of treatment the burn wounds which can be recommended to all the patients and clinics. However, a specific approach is required for treatment of severe burns which makes all these technologies individualized. If we consider decrease of cicatrices and contractures as a criterion of the patients' life quality, then use of cultured cells will be the main part of dermal equivalents. So if we want the technology to provide the required scope of functional dermal equivalent manufacture at a reasonable price, it is required to set up a bank of allogenic fibroblasts, both local and regional, in order to meet the requirements of a medical center which specializes in treatment of severe burns and which is particularly invaluable in case of mass damage.

SUMMARY

Our studies prove that 10 years of facial plastic using a full-thickness free skin graft results twice reduced indications for reconstructive surgeries and twice reduced anti-scarring treatment in outpatient department.

Reconstructive surgeries helped to remove insignificant deformations of the scar edges in palpebral area and epicanthus. We couldn't objectively estimate indications for esthetic surgeries because we don't perform them in our burn center and patients can do esthetic surgeries in commercial centers of plastic surgery. However, the developed techniques of plastic surgery using a full-thickness skin graft in the acute phase of burns significantly reduces the risk of scar tissue formation, and also gives positive esthetic results in just one surgery. Therefore, there are no indications for staged reconstructive surgeries.

Since 2010 (during 8 years) 10 facial plastic surgeries using one full-thickness autograft were performed in Krasnodar burn center (including three plastic surgeries using autograft and autofibroblasts since 2017). From 1300 patients with burn injury (including children) treated annually in our center this technique is indicated and performed in 1-2 patients.

This method of plastic surgery and technical aspects of surgical treatment are put into practice in Russian burn units and centers.

In 2014 the proposed technique was awarded with the main medical award of Russia "Prizvanie" in the nomination "For a new method of treatment". According to the expert council of the Award and Russian Health Ministry our method has scientific and clinical priorities in Russian and world medicine.

New methods of treatment continue the old tradition of excellent and creative Russian medical school...»
Deputy prime minister of the Russian Federation
Olga Yu.Golodets

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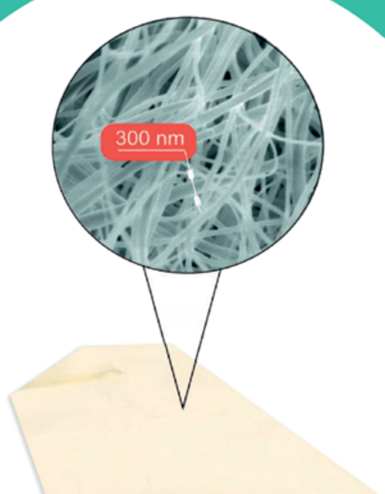

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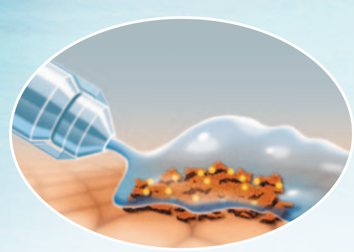

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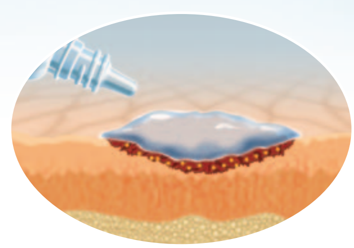

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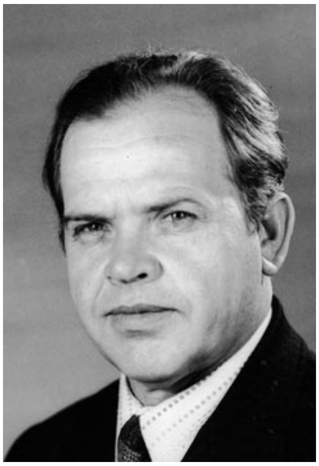

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Participants of the International Conference.
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The Prizvanie Award Ceremony (2014) in the nomination 'For a new method of treatment' (left-to-right: Ivaschenko Yu.V, Marchenko D.N., Polyakov A.V., Malysheva E.V., Babichev R.G., Skvortsova V.I., Porkhanov V.A., Bogdanov S.B., Philippov E.F).

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