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LONG-TERM RESULTS OF PLASTY OF GRANULATING WOUNDS OF THE DISTAL EXTREMITIES WITH MESH AND SOLID SKIN AUTOGRAFTS OF BURN WOUNDS IN CHILDREN

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Background. The widespread and not always justified use of mesh autografts in children with burns leads to the development of severe contractures and dislocations in the joints in the first year after the restoration of the skin.
Aim. In this study, the long-term results of plasty of granulating wounds of the distal extremities with mesh skin autografts in children with burns were evaluated.
Materials and methods. In Turner Institute's clinic of trauma sequale, from 2012 to 2018, we treated a total of 153 children who developed scar deformities of the hands and feet after plastic surgery with continuous and mesh skin autografts. The control group (42 patients) consisted of patients after wound plasty with skin autografts. The study included patients with a total area of deep burns within 1%–15% of the body surface. The follow-up period ranged from 7 months to 3 years. Objective examination with anamnestic and radiological data analysis was used. The classification by B.V. Parin (1946) was used to estimate the degree of limitation of the range of motion in the joint. A set of standard analysis tools included in SPSS Statistics v23 ×64 was used to carry out statistical data processing.
Results. The number of deformities formed on the background of the surviving mesh autograft is 2 times more than after the plasty of granulating wound with a solid skin autograft (54.4% and 20.6%, respectively). Dislocations in the wrist joints on the background of mesh plasty of wounds with a skin autograft developed in a mean time of 15.33 ± 1.28 months. Moreover, dislocations in the metatarsophalangeal joints of the foot under the extensor contracture were diagnosed after a mean of 7.52 ± 0.23 months ($p < 0.05$), with flexion contracture at 7.00 ± 0.38 months, and multiplanar deformity with dislocation at the subtalar and metatarsophalangeal joints was observed to form at 34.0 ± 10.0 months.
Conclusion. There was a 3 times higher rate of visit among patients with scar deformities developed after the use of mesh autografts in the area of the joints of the hand and foot, and the development of deformities was 4–6 months shorter than in the plasty of granulating wounds with solid skin autografts. The lack of a differentiated approach to the choice of the restoration method of the skin and conservative preventive therapy in children with burns leads to the need for reconstructive treatment in the near future.

Keywords: mesh grafts; free skin grafts; scar deformity; scar contracture.

ОТДАЛЕННЫЕ РЕЗУЛЬТАТЫ ПЛАСТИКИ ГРАНУЛИРУЮЩИХ РАН ДИСТАЛЬНЫХ ОТДЕЛОВ КОНЕЧНОСТЕЙ СЕТЧАТЫМИ И СПЛОШНЫМИ КОЖНЫМИ АУТОТРАНСПЛАНТАТАМИ У ДЕТЕЙ С ОЖОГАМИ

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Обоснование. Широкое и не всегда обоснованное использование сетчатых аутотрансплантатов у детей с ожогами приводит к развитию тяжелых контрактур и вывихов в суставах уже в первый год после восстановления кожного покрова.
Цель — оценить отдаленные результаты пластики гранулирующих ран дистальных отделов конечностей сетчатыми кожными аутотрансплантатами у детей с ожогами.
Материалы и методы. С 2012 по 2018 г. в клинике последствий травм ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России пролечено 153 ребенка с рубцовыми деформациями кистей и стоп, развившимися после

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пластики сплошными и сетчатыми кожными аутотрансплантатами. Пациенты после пластики ран спошными кожными аутотрансплантатами вошли в группу контроля (42 пациента). В исследование были включены пациенты с общей площадью глубоких ожогов в пределах 1–15 % поверхности тела. Сроки наблюдения составили от 7 мес. до 3 лет.

Всем пациентам проводили объективное обследование с анализом анамнестических и рентгенологических данных. Степень ограничения амплитуды движений в суставе оценивали по классификации Б.В. Парина (1946). Статистическую обработку данных проводили с использованием набора стандартных средств анализа, входящих в состав пакета прикладных программ SPSS Statistics v23 ×64.

Результаты. Количество деформаций, сформировавшихся на фоне прижившего сетчатого аутотрансплантата, было в 2 раза больше, чем после пластики гранулирующей раны сплошным кожным аутотрансплантатом (54,4 и 20,6 % соответственно).

Вывихи в суставах кисти на фоне пластики ран сетчатым кожным аутотрансплантатом развивались в сроки 15,33 ± 1,28 мес., вывихи в плюснефаланговых суставах стопы при разгибательной контрактуре — в сроки 7,52 ± 0,23 ($p < 0,05$) мес., при сгибательной контрактуре — в сроки 7,00 ± 0,38 мес. и многоплоскостные деформации с вывихами в подтаранном и плюснефаланговых суставах — в сроки 34,0 ± 10,0 мес.

Заключение. Обращаемость пациентов по поводу рубцовых деформаций, развившихся после использования сетчатых аутотрансплантатов в области суставов кисти и стопы, в 3 раза выше, а сроки развития деформаций на 4–6 мес. меньше, чем при пластике гранулирующих ран сплошными кожными аутотрансплантатами.

Отсутствие дифференцированного подхода к выбору метода восстановления кожного покрова и консервативной профилактической терапии у детей с ожогами приводит к необходимости реконструктивного лечения уже в ближайшей перспективе.

Ключевые слова: сетчатые аутотрансплантаты; свободная кожная пластика; рубцовые деформации; рубцовые контрактуры.

Background

It is well-known that grafting granulating wounds with sieve skin autografts is a lifesaving treatment method for patients with extensive burns, particularly when there is a shortage of donor skin [1–4].

Some areas, such as the face, hands and feet, joint areas, and perineum are absolutely contraindicated for grafting with sieve autografts [1–6]. The limitations are because these areas are subject to much greater retraction than continuous grafts, which may result in unsatisfactory cosmetic outcomes that are difficult to correct [7–10].

The widespread, and not always justified, use of sieve autografts in pediatric practice often leads to drastic consequences. As a result of sieve autograft retraction in a growing child's body, severe contractures and dislocations in the joints develop within the first year of skin restoration after a burn [11–15].

This study aimed to evaluate the long-term results of grafting granulating wounds in the distal extremities using sieve skin autografts in pediatric patients with burns.

Material and methods

A total of 153 pediatric patients who had cicatricial deformities of the hands and feet, which developed after granulating wounds were grafted with continuous and sieve skin autografts, were examined and treated at the Turner Scientific Research Institute of Children's Orthopedics from 2012 to 2018. Patients who underwent wound grafting with continuous skin autografts constituted the control group ($n = 42$).

The study included patients with a total deep burn area of 1%–15% of the body surface. The criteria for comparing the treatment results were the nature of the surgical treatment during the acute period after the injury, the term of development, and severity of the deformities. The follow-up period ranged from 7 months to 3 years.

All pediatric patients underwent a clinical examination, where the anamnestic and objective findings were analyzed along with an X-ray examination to assess the severity of the osteoarticular changes. B.V. Parin's classification (1946) was used to indicate the degree of limitation in joint range of motion. According to this classification, the 1st degree of contracture indicated a minor limitation in limb function at the maximum range of movement, the 2nd degree indicated a 50% limit in the range of motion, the 3rd degree indicated a <50% limitation of the range of motion, and the 4th degree indicated complete loss of motion caused by the cicatricial fusion of the surfaces [16].

Table 1

The number and proportion of patients with cicatricial deformities of the distal extremities, depending on the option of the skin restoration

Localization	Continuous autograft	Sieve autograft	Total
Hand and wrist joint, *n*	25	79	104
Feet and ankle joint, *n*	17	32	49
Total	42 (24.5 %)	111 (72.5 %)	153 (100 %)

Table 2

Types and frequency of cicatricial deformities of the hand, depending on the option of restoring the skin in patients who applied for reconstructive treatment

Type of deformity	Continuous autograft	Sieve autograft
Interphalangeal joint flexion contractures	15 (60 %)	54 (68.3 %)
Extensor contractures in the metacarpophalangeal and interphalangeal joints	10 (40 %)	22 (27.8 %)
Contractures with joint dislocations	–	3 (3.8 %)
Total	25	79

Statistical data processing was performed using a set of standard analysis tools included in the SPSS Statistics v23 ×64 (IBM Corporation, Armonk, NY, USA) software applications package.

Results

An analysis of the anamnestic data and available medical records showed that patients in the acute period of burn injury received infusion and antibiotic therapy. Staged necrectomy, with conservative preparation of the granulating wounds, was performed for these patients, followed by additional grafting with continuous or sieve skin autografts.

Preventive anti-scar treatments using the appropriate drugs, compression therapy, and preventive immobilization were not performed.

Table 1 shows the number and proportion of patients treated at the Turner Scientific Research Institute for Children's Orthopedics due to secondary deformities of the hands and feet after skin restoration using continuous and sieve skin autografts. Cicatricial deformities requiring surgical treatment were much more likely to develop after skin restoration with a sieve skin autograft. Twice the number of deformities were generated with an established sieve autograft than with a continuous skin autograft.

Table 2 presents the main reasons (the hand deformities) for the patient visits at our clinic for surgical treatment. The most severe deformities, with dislocations in the joints, developed after skin restoration with a sieve skin autograft. The most common deformity requiring surgical treatment was flexion contracture in the interphalangeal joints.

Clinically, within 1–2 years after the plastic surgery, the established sieve autograft presented with tuberous relief, pronounced retraction, and hypertrophy along the junction, with the intact skin resulting in an unsatisfactory functional and esthetic result in all patients (Fig. 1).

The trend for retraction, inherent in sieve skin autografts, led to a relatively rapid development of joint contractures (Fig. 2, 3).

Grafting the granulating wounds with a sieve skin autograft in the small joint areas led to the development of dislocations in the joints over a short period of time (Fig. 3).

The use of sieve autografts in the foot joints led to drastic consequences. The foot is a segment that bears increased axial mechanical loads. A constant load on a deformed foot accelerates the development of secondary pathological changes with deformities in the articular surfaces.

Table 3 shows the types and quantitative ratios of the cicatricial deformities that developed after

Fig. 1. Image of a 3-year-old patient diagnosed with flexion cicatricial contracture in the interphalangeal joints of the finger II due to retraction of the sieve skin autograft one year after skin restoration

Fig. 2. Image of a 5-year-old diagnosed with extensor cicatricial contractures in the metacarpophalangeal joints of the fingers I–V, with adduction contracture in the metacarpophalangeal joint of the finger I, due to retraction of the sieve skin autograft 8 months after skin restoration

a *b* *c*

Fig. 3. Image of a 3-year-old diagnosed with extensor-abduction cicatricial contracture in the joints of the finger I due to retraction of the sieve skin autograft 11 months after the grafting of a granulating wound with a sieve skin autograft. *a, b* — shortened cicatricial cord; *c* — dislocation in the metacarpophalangeal joint of the finger I

various options for restoring foot skin. The most severe foot deformities developed after skin restoration using a sieve skin autograft. Twice as many deformities required surgical treatment after transplantation with sieve autografts than after transplantation with continuous skin autografts.

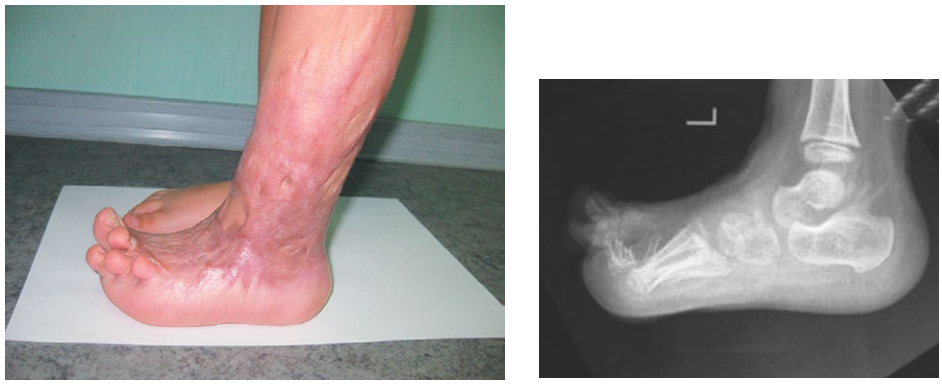
The most common pathology was the extensor contracture of the foot joints, with dislocations in the metatarsophalangeal foot joints (Fig. 4).

Flexion contractures in the metatarsophalangeal joints, which are generally associated with a lower frequency of burns on the plantar surface of the

Table 3

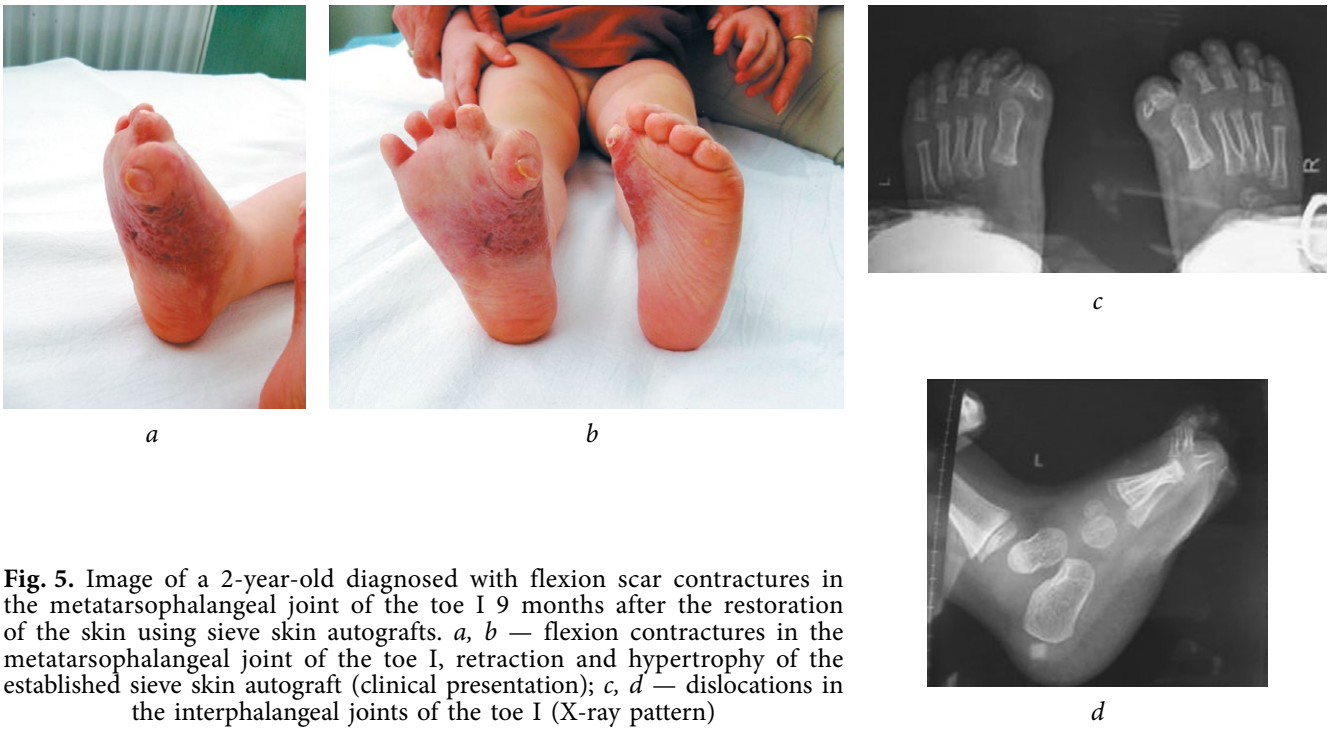
Types and frequencies of cicatricial foot deformities depending on the type skin restoration in patients who sought reconstructive treatment

Type of deformity	Continuous autograft	Sieve autograft
Extensor contracture in metatarsophalangeal joints with dislocations	17 (100 %)	26 (81 %)
Flexion contracture in the metatarsophalangeal joints with dislocations	–	3 (9.3 %)
Multiplanar deformity involving several joints of the foot and a change in the shape of the bones	–	3 (9.3 %)
Total	17	32



a *b*

Fig. 4. Image of a 4-year-old diagnosed with extensor cicatricial contractures in the metacarpophalangeal joints of the left foot with dislocations one year after grafting the granulating wound of the foot dorsum with a sieve skin autograft. *a* — shortened planar scar of the left foot dorsum, extensor contractures in the metatarsophalangeal joints (clinical presentation); *b* — dislocations in the metatarsophalangeal joints (X-ray pattern)



a *b* *c* *d*

Fig. 5. Image of a 2-year-old diagnosed with flexion scar contractures in the metatarsophalangeal joint of the toe I 9 months after the restoration of the skin using sieve skin autografts. *a, b* — flexion contractures in the metatarsophalangeal joint of the toe I, retraction and hypertrophy of the established sieve skin autograft (clinical presentation); *c, d* — dislocations in the interphalangeal joints of the toe I (X-ray pattern)

feet, were less commonly observed in this study. The transplantation of a sieve autograft on to the foot's supporting surface always led to scar tissue hypertrophy and progressive trophic disorders (Fig. 5).

The use of sieve skin autografts in the ankle joint and the Achilles tendon caused a rapid development of flexion or flexion-extension contractures with a persistent pathological establishment. Scar tissue in the Achilles tendon, as a rule, is hypertrophied; recurrent trophic disorders accelerate the contracture development (Fig. 6).

In some cases, surgery with sieve skin autografts resulted in the development of multiplanar foot

Fig. 6. Images of an 11-year-old patient diagnosed with flexion-extension contracture in the ankle joint 1.5 years after grafting of the granulating wound in the lower leg and ankle joint with a sieve skin autograft

a *b* *c*

Fig. 7. Images of a 2.5-year-old patient diagnosed with extensor-abduction cicatricial contracture in the metatarsophalangeal joints III, IV, and V of the right foot 1.5 years after skin restoration using a sieve skin autograft. *a, b* — hypertrophic scar on the outer surface of the right ankle joint, lateral displacement of the forefoot (clinical presentation); *c* — dislocation in the metatarsophalangeal joint V (X-ray image)

deformities, which required long-term and multi-stage surgical treatments. In Fig. 7, a hypertrophic scar of the lateral surface of the foot, ankle joint and lower leg led to progressive lateral forefoot displacement. The long-term growth of the foot under conditions of asymmetrical cicatricial traction can cause critical consequences that cannot be completely eliminated.

Figure 8 shows a severe equino-valgus-abduction deformity of the foot in a 7-year-old child due to a shortened scar that passes from the external arch of the foot to the lateral surface of the ankle joint.

The long-term lateral cicatricial traction led to a gradual lateral displacement of the bones of the ankle, subtalar, and calcaneocubital joints, which progressed to the transverse tarsal joint and the tarsometatarsal joint, resulting in a multiplanar hindfoot and midfoot deformities. The active load on the gradually deforming foot accelerated fibrosis of the ligaments and joint capsules, the development of secondary deformities in the tarsal bones, and the progression of disorders in spatial relationships in the joints.

As shown in Table 4, the average period for development of severe hand and foot contractures

a *b* *c*

Fig. 8. Images of a 7-year-old diagnosed with multiplanar cicatricial deformity of the left foot 5 years after grafting the granulating wound of the lower leg and ankle joint with a sieve skin autograft. *a* — a shortened hypertrophic cicatricial cord along the edge of the established sieve skin autograft (clinical presentation); *b* — lateral displacement of the fore part of the left foot (clinical presentation); *c* — radiographic image showing supination decentration of the talus bone, rotational and equinus dislocation: complete dissociation of the talus and calcaneal bones at the level of the anterior articular facet, the forefoot in a pronounced supination position consensual with the calcaneal bone, the navicular bone is articulated with the medial-plantar surface of the head and neck of the talus bone

Table 4

Terms of development and types of cicatricial deformities in pediatric patients after skin restoration using continuous and sieve skin autografts

Segment	Type of deformity	Terms after restoration of the skin, months	
		continuous skin autograft	sieve skin autograft
Hand	Flexion contractures in interphalangeal joints of III–IV degrees	12.5 ± 0.68 (n = 15)	7.18 ± 0.29* (n = 54)
	Extensor contractures in the fetlock and interphalangeal joints	12.25 ± 0.93 (n = 10)	7.22 ± 0.30* (n = 22)
	Grade IV contractures with dislocations in the joints	–	15.33 ± 1.28 (n = 3)
Foot	Extensor contracture in metatarsophalangeal joints with dislocations	14.23 ± 0.45 (n = 17)	7.52 ± 0.23* (n = 26)
	Flexion contracture in the metatarsophalangeal joints with dislocations	–	7.00 ± 0.38 (n = 3)
	Multiplanar deformity involving several joints, dislocations, and bone shape changes	–	34.0 ± 10.0 (n = 3)

Note. * $p < 0.05$.

with established sieve autografts is significantly shorter than with continuous skin autografts. The development of joint dislocations with the use of sieve autografts is particularly noteworthy.

Discussion

Grafting the granulating wounds with sieve autografts results in the formation of coarse scar tissues, which subsequently lead to significant functional disorders and esthetic problems. The adverse properties of scars formed at the grafted sieve skin autograft site can lead to patient disabilities; these properties form the basis for determining indications and contraindications for using sieve autografts in burn surgery [1, 2, 6, 8–10].

The indications for grafting the granulating wounds with sieve skin autografts include the presence of an extensive deep burn, exceeding 30%–40% of the body surface, and a shortage of donor skin resources [1–4].

Sieve skin autografts are contraindicated in several parts of the body (face, neck, hands, perineum, and joint areas) [1–6]. However, in some regions of Russia, these autografts are used in those areas, even though their use is contraindicated. The distal extremities are most commonly affected by this treatment.

An undifferentiated approach to granulating wound repair, combined with the absence of a conservative preventive treatment and follow-up, leads to disastrous results in the form of the rapid development of dislocated joints (7 months after the skin restoration). It is noteworthy that severe deformities in pediatric patients develop after plastic surgery on granulating wounds with continuous skin autografts, which is also a consequence of the lack of conservative treatment and medical examination.

Analysis of the data from our study indicated the need for a differentiated approach regarding the treatment method for granulating wound grafting in burn patients. Sieve autografts should be used based on the indications and by taking the wound location into account because the use of plastic surgery in the joints of the hand and foot necessitates additional multi-stage surgical treatments. In severe cases, this may lead to disability.

Conclusion

The lack of a differentiated approach toward skin grafting and conservative preventive therapy in pediatric patients with burns results in the need

for additional reconstructive treatment in the near future.

Plastic surgery on granulating wounds with sieve autografts in functionally active zones in pediatric patients with limited burns is an unreasonable intervention that foredooms the child to multi-stage surgical treatment and long-term rehabilitation.

The number of patients who came for treatment of cicatricial deformities, which developed after using sieve autografts in the hand and foot joints, was three times greater than those who came after treatment with continuous skin grafts; moreover, the duration for the development of deformities was lower in the patients who were treated with sieve autografts.

Additional information

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Conflict of interest. The authors declare no obvious or potential conflicts of interest related to the publication of this article.

Ethical review. The study was performed in accordance with the ethical standards of the Helsinki Declaration of the World Medical Association as amended by the Ministry of Health of Russia, approved by the ethics committee of the Turner Scientific Research Institute for Children's Orthopedics (protocol No. 2 of 01.03.2013).

Patients and/or their representatives gave their consent for processing and publication of personal data.

Contribution of the authors

O.V. Filippova performed analysis of the anamnesis and objective data of patients, statistical processing of the material, wrote all sections of the article, collected and analyzed literature data.

K.A. Afonichev was involved in the development of the study concept, selection of patients, analysis of the patient's objective data, analysis of literature data, and editing.

M.S. Nikitin performed the selection of patients, analysis of the patient's objective data.

A.V. Govorov performed the selection of patients, analysis of the patient's objective data.

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