

# TREATMENT OF POST-BURN SCAR DEFORMATIONS USING TISSUE EXPANSION AND ENDOSCOPY

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**SUMMARY.** *Background.* The essential drawbacks of conventional tissue expansion, a technique widely used in reconstructive surgery, are its significant duration and the high complications rate. The experience of our clinic covers 329 patients treated with this method from 1987 to 2006. The mean time of expansion was previously  $72 \pm 2$  days ( $\pm$  SD) and the rate of local complications was 38.6%. We applied effective new approaches to this method in order to reduce its drawbacks, i.e. the endoscopic implantation of expanders, intensive expansion, and a modified technique of elevation of an expanded flap. *Methods.* Twenty-seven patients treated in the A.V. Vishnevsky Institute of Surgery between 2001 and 2006 for post-burn scar deformities underwent endoscopic implantations of 46 silicone expanders in various anatomical areas. High-grade tissue expansion was initiated immediately after implantation. The elevation of the reconstructed flap was performed, including defective tissues in the flap, after which the expander was removed and the expanded tissues were transposed. *Results.* With the help of the techniques developed, it was possible to reduce the mean expansion time from 72 days to 34 (less than half) and to reduce the complications rate from 38.6% to 6.5%. *Conclusions.* Endoscopic expander implantation, the accelerated technique of tissue expansion, and modified elevation of the expanded flap enabled us to considerably improve results in the treatment of post-burn scar deformities, using the tissue expansion method.

## Introduction

In the last decade there has been a marked and steady growth in the number of patients suffering from post-burn and post-traumatic soft tissue deformities and scar contractures causing functional and cosmetic defects. Such "defects" of appearance promote alterations in the patients' psychoemotional conditions, generate feelings of hopelessness, inferiority, and uncertainty, and reduce a person's mental and working capacity, frequently leading to the development of concomitant diseases of psychosomatic origin such as neurosis, angina pectoris, and hypertension.

Surgical treatment is frequently limited by the scarcity of adequate soft tissues available for reconstruction. Over the last 25 years tissue expansion has become a technique for overcoming such soft-tissue limitations.<sup>1-4</sup> This method possesses the unique ability of generating skin with an almost perfect match of colour, texture, and sensation required for reconstruction in a specific area. Compared with other methods of plastic surgery, tissue expansion facilitates the closing of extensive soft-tissue defects without additional scars in donor areas.<sup>1,5,6</sup>

In the period from 1987 to 2006 tissue expansion was used in the treatment of 329 patients with post-burn and post-traumatic cicatricial deformations in the A.V. Vishnevsky Institute of Surgery. A total of 780 expanders were

implanted in various anatomical areas. However, the method presented some essential drawbacks, i.e. its significant duration ( $72 \pm 2$  days ( $\pm$  SD) and the high complications rate (up to 38.6%). Our data are consistent with those in the literature, according to which the expansion lasts 2-3 months and the complications rate ranges from 5% to 70%.<sup>4, 6-12</sup> This considerably limits the possibilities of wide clinical usage of tissue expansion.<sup>2,6,7</sup>

The above considerations led us to seek effective new approaches to this method that would enable us to considerably reduce the duration of treatment and the complications rate. We used an endoscopic expander implantation, intensive expansion, and a modified technique for elevation of the expanded flap.

## Patients and methods

We used an endoscopic implantation of 46 expanders in 27 patients with post-burn scar deformities between December 2001 and December 2006. The patients' ages varied from 15 to 44 yr (mean,  $25.1 \text{ yr} \pm 0.6$ ) ( $\pm$  SE); 18 patients were female and 9 male. Expanders were implanted in the head, face, neck, chest, abdominal wall, scapular, shoulder, and forearm and calf areas.

### Expanders

Silicone expanders (Plastis-M, Moscow) in hemi-

spherical, oblong, or cylindrical form were used (Fig. 1). Their base size ranged from 80 x 35 to 130 x 50 mm and their volume from 50 to 500 ml.

*Endoscopic technique of expander implantation*

In the early days, sites for tissue expansion, the expander sizes, and the incision line for the creation of a pocket were selected and marked on the skin.

The incision was made within the defect area that it was planned to excise, making use of expanded tissues. The incision was as remote as possible from the expander pocket, it was 10 mm long (in relation to the size of the endoscopic instrument), and its direction was parallel to that of the tissue expansion tension vectors (Fig. 2).

The second stage was the dissection of the expander pocket in the required anatomical stratum. The expanders were placed under a galea aponeurotica on the head and, if possible, under a superficial fascia in all other areas. This provided uniform tissue expansion and prevented pressure sores and excessive thinning of subdermal fat.

A primary tunnel (approximate length, 2 cm) was created bluntly from the incision to the planned expander site. An ESDP endoscopic videosystem (R. Wolf, Germany) (Fig. 3) was then inserted with a working tool. This instrument made it possible to implant the expander through one remote incision, since it was fitted with a camera, a gas insufflator, and a channel for a working instrument, providing the opportunity of cutting tissues in conditions of haemostasis. The working tool was always in front of the camera at the centre of the field of vision. The instrument's L-shaped form was very convenient, making it easy to lift the dissected tissues mechanically and to create sufficient space for the dissection optical cavity. A coagulation hook, a dissector, or scissors were used as a working tool. Carbonic gas (pressure, 15-17 mm Hg) was insufflated through the ESDO channel in order to maintain an optical cavity in the soft tissues and to simplify the endoscopic manipulations. The expander pocket was created on the basis of the pre-operative markings, with meticulous haemostasis (Fig. 4).

An empty expander was implanted in the cavity created, straightened inside, and filled with normal saline solution. The operative wound was closed in two layers with two single sutures. Drainage was not used, in view of the adequate haemostasis and the absence of free cavities in the tissues.

Ports were placed subdermally or externally through the small apertures (2 mm, depending on the diameter of the connecting tube). It was enough to change the anti-septic dressings once every two days to prevent infection.

*Intensive technique of tissue expansion*

High-grade tissue expansion was initiated at once on the operating table, filling the expanders in 3-4 weeks us-

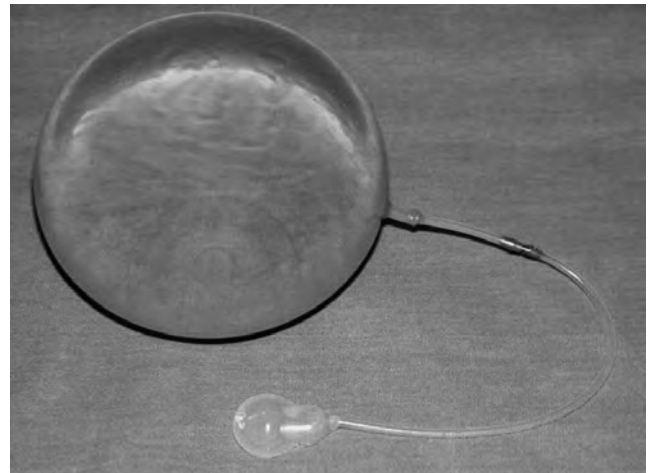


Fig. 1 - Plastis-M silicone expander.

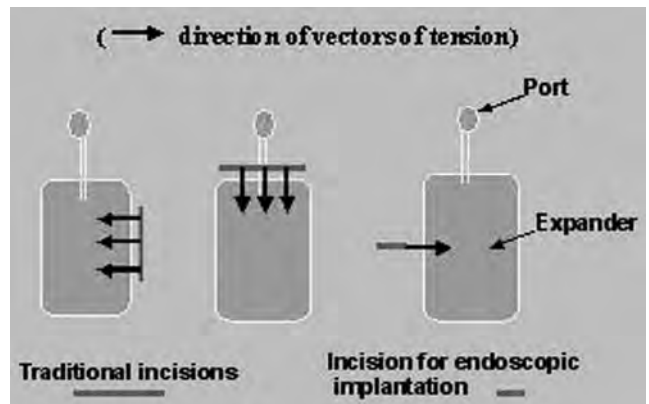


Fig. 2 - Scheme of orientation of tension vectors in relation to post-operative wounds in traditional and tissue expander implantation.

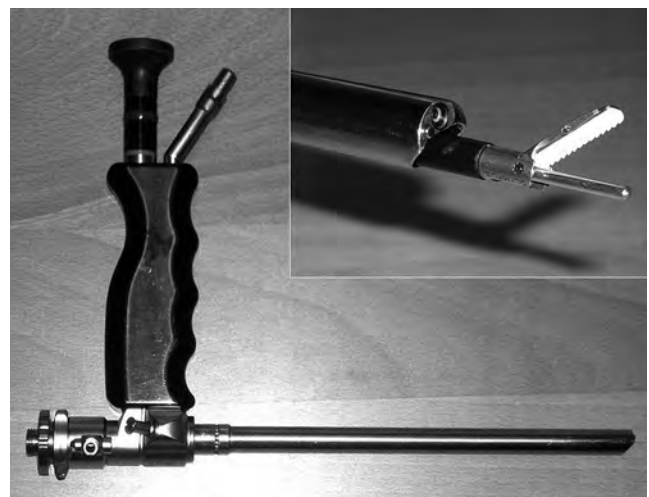


Fig. 3 - Endoscopic videosystem (R. Wolf, Germany) permitting simultaneous visualization, gas infusion, tissue dissection, and coagulation.



**Fig. 4** - Endoscopic dissection of expander pocket via distant small incision with good visualization and precise haemostasis.



**Fig. 5** - Patient N., 17 years old, with post-burn scar sequelae on left cheek and neck.



**Fig. 6** - Two endoscopically implanted expanders and sufficient tissue gain achieved by intensive expansion in 27 days.

ing expansion with a conventional implantation technique (up to 350 ml). This eliminated any possible “dead spaces” between an expander and the surrounding tissues and thus made it possible to prevent seromas, haematomas and infection of the pocket. Expanders were filled in such a way as not to interrupt the blood supply to the expanded tissues, without taking any notice of post-operative wound dehiscence.

Filling was done daily or every other day with normal saline solution and was suspended on the appearance of signs of altered blood circulation in the expanded tissues (hyperaemia, pallor). Analgesic drugs were not used. The volume of the infusions depended on the anatomical area and the volume of the expander, ranging from 15 to 60 ml in one tissue expansion session.

Measuring oxygen pressure in the expanded tissues with a TCM 400 gas analyser (Radiometer, Denmark) was an expedient method of objective control. During filling the pressure should not go below 10 mm Hg (TcPO<sub>2</sub> of healthy intact skin is 55-60 mm Hg).

Tissue expansion was performed until sufficient tissue gain for reconstruction had been achieved (Figs. 5,6).

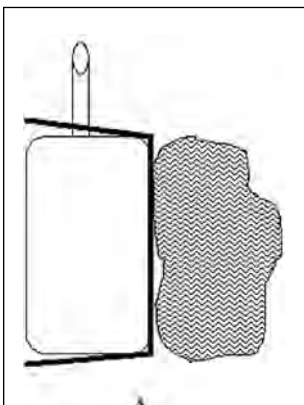
#### *Modified elevation of expanded tissues*

The anatomical blood supply of the expanded flaps was taken into the account during the planning and performance of reconstruction by expanded tissues.

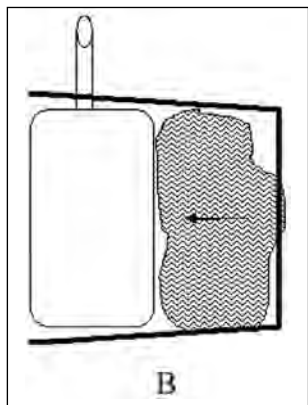
An endoscopic expander implantation enabled us to apply a new technique of elevation for expanded flap that permitted a more effective utilization of the flaps’ resources without any retraction.

In the conventional technique, expansion was continued until the area of expanded tissues was 20% greater than the defective area. It was performed to prevent tissue deficit after reconstruction because, after removal of the implant, expanded tissues retracted by approximately 20% or 2-4 cm, depending on expander size. This retraction was caused by elastic and collagenic fibres, fibroblasts, and myofibroblasts of derma and capsule.<sup>13,14</sup> The duration of tissue expansion was therefore prolonged.

A traditional reconstruction by expanded tissues was performed as we shall now describe. An expander pocket was opened with an incision on the edge of the pathological and expanded tissues that was practically an incision from the previous implantation (Fig. 7A). The implant was then taken out and the size of the expanded tissues was calculated, on the basis of which defective tissues were excised, with coagulation of bleeding vessels. This procedure usually took from 30 to 60 min, during which time retraction occurred. To avoid this deficit of expanded tissue on reconstruction, the following formula was used:  $Snes. = Sexp. - Sexp.base = 1.2 \times Sdef.$ , where *Snes.* is the surface area of tissues necessary for plastic surgery; *Sexp.* is the surface area of expanded skin above an expander;



**Fig. 7A** - Scheme of incisions for dissection and mobilization of expanded flap with conventional reconstruction.



**Fig. 7B** - Scheme of incisions for dissection and mobilization of expanded flap with modified reconstruction and inclusion of defective tissue in flap (wide continuous lines show incisions; arrow shows direction of mobilization).



**Fig. 8** - Mobilization of cutaneous or fasciocutaneous layer (under defect) towards expander pocket with subsequent haemostasis. Subdermal fat and if possible the superficial fascia is included in the flap in order to maintain blood supply to distal parts.

*Sexp.base* is the surface area of the expander base; and *Sdef.* is the surface area of the defect.

Twenty per cent of the gain achieved by expanded tissues was thus lost using this technique. The period of tissue expansion was therefore prolonged as it was necessary to reach *Snes*.

The modified technique became possible after study of endoscopic expander implantation allowed maximum use of expanded tissue resources. Planning of the defect area to be excised was done before the operation on the basis of the tissue gain due to the expansion. Incisions were made on the basis of this plan (*Fig. 7B*), after which mobilization of a cutaneous or fasciocutaneous layer (under the defect!) towards an expander pocket was carried out, with subsequent haemostasis. The subdermal fat and, if possible, the superficial fascia were included in the flap in order to save the blood supply in distal parts (*Fig. 8*). When during mobilization an expander pocket was reached, the defective tissues had already been cut from subjacent tissues and haemostasis had been achieved on the wound surface. After that the expander pocket was opened and the implant was removed. The expanded flap was placed on the defect, final fitting was done, and tissues scheduled for removal were cut from the flap (*Fig. 9*). The wound was closed with two layers of sutures. Using this technique, there was no time for the retraction of expanded tissues. In view of the possibility of tissue deficit due to complete excision of all extensive defects, the strip of pathologic tissues, where the blood supply was not interrupted by the incision for implantation of the expander, was left in the distal part of the flap.

The advantage of this modified technique of recon-



**Fig. 9** - Expanded flap transferred to defect, final fitting performed, and tissues scheduled for removal excised from flap.

struction was thus the reduction in expansion time, due to maximum use of expanded tissues, without losing up to 20% of the gain because of retraction and without the risk of tissue deficit for plastic surgery.

#### Statistical analysis

The licensed program Statistica 6.0 was used for statistical analysis, using the following parameters: mean val-

**Table I** - Comparison of techniques of implantation and tissue expansion

Criteria of comparison	Conventional implantation and expansion	Endoscopic implantation and intensive expansion
Mean expansion time (days)	71.8 ± 1.7 (± SE)	33.6 ± 2.3 (± SE)
Complications (percentage of expansions)		
Seroma	11.4	0
Haematoma	6.8	3.2
Infection	14.6	0
Wound dehiscence	8.0	0
Pressure sore	15.3	3.2
Failure of expansion due to complications	5.6	0
Total*	38.6	6.5
	* <i>p</i> < 0.05	



**Fig. 10** - Same patient three months after reconstruction with expanded tissues.

ue (M), average standard deviation, and Student's t-test; the hypothesis of equality of average (frequencies) in two groups was rejected at a significance value of  $p < 0.05$  for quantitative attributes and the  $\chi^2$  criterion for qualitative attributes.

### Results

For the comparison of techniques we considered the results, the terms of treatment, and the complications rates.

The most frequent complications with the conventional technique were seromas (11.4%), haematomas (6.8%), infections (14.6%), dehiscence of post-operative wounds (8.0%), and pressure sores (15.3%) (Table I). Wound dehiscence and pressure sores were associated with seromas, haematomas, or infections of the expander pocket in respectively 63.6% and 47.6% of cases. This testified to the important role of these in the development of trophic alterations in expanded tissues. The complications had a negative influence on tissue expansion, its duration, and the results of treatment: in 24 cases (5.4%) using the conventional technique, tissue expansion failed because of complications such as infection (2.5%), pressure sores (1.6%), and wound dehiscence (1.3%).

With the new techniques, as reported above, a

haematoma was observed in one case (3.2%) and a pressure sore (due to an accidental trauma in the expansion site) also in one patient (3.2%). There were no failed expansions, and all the transferred expanded flaps survived after reconstruction (Fig. 10). The wounds healed uneventfully by primary intention. Thus the commencement of tissue expansion immediately after implantation and the intensive filling technique did not increase the trophic alteration rate in the expanded tissues.

The mean duration of tissue expansion using an endoscopic expander implantation, intensive expansion, and modified reconstruction was less than half than using the conventional technique, i.e.  $33.6 \pm 1.7$  days ( $\pm$  SE) compared to  $71.8 \pm 2.3$  days ( $\pm$  SE) ( $p < 0.05$ ).

The new techniques therefore enabled us to considerably reduce the complications rate from 38.6% to 6.5%, i.e. by 32.1% ( $p < 0.05$ ) and to decrease expansion time by 38 days, thus reducing patient discomfort.

### Discussion

Tissue expansion is an effective method of reconstructive and plastic surgery.<sup>15</sup> However, its essential drawbacks of significant duration and a high local complications rate considerably limit its wide clinical application.

We analysed factors that might consent a reduction of these limits of expansion: it was necessary "to exclude" the time required for healing of an implantation wound, to prevent complications, and to develop a reconstruction technique without retraction of the expanded tissues and therefore without the need to waste time on overexpansion up to 20%. A reliable technique was necessary to reduce the risk of complications to a minimum.

Conventional post-operative implantation wounds did not allow tissue expansion within 10-14 days before healing. This period was even longer in the event of complications. This time was completely inadequate for tissue expansion. Reduction of the length of the incision was limited by the need of good visual control and of adequate operative space for maintenance of haemostasis.

With the traditional technique a surgeon has to balance between insufficient filling (seroma and infection) and overfilling (post-operative wound dehiscence) in the first two weeks after an implantation. This fortnight's delay promotes the development of a thicker capsule around the expanders that complicated tissue expansion<sup>16</sup> and increased the retraction of expanded tissues.<sup>14</sup> Capsular thickness is proportional to expander pressure, reaching its maximum after approximately two months of expansion.<sup>17</sup> Thus, with conventional techniques, the thick capsule, after two or three months of expansion, limited the expanded tissues' mobility. To overcome this, surgeons have to make several parallel incisions for capsular release that can impair

damage the flap's blood supply.

Endoscopic techniques and instruments made it possible to create the required cavity for an expander in the selected anatomical layer of tissues, with good haemostasis control through remote 5-10 mm incision(s) made parallel to the tension vectors.<sup>16,18-21</sup> A high-grade expansion process was therefore immediately initiated immediately after implantation of the expander.<sup>22,23</sup> Endoscopic implantation of expanders appeared to effectively prevent complications. A careful check of all the areas of a newly formed pocket, plus precise haemostasis, served to prevent haematomas. Some minor incisions (5-10 mm), made parallel to tension forces, enabled us to initiate a high-grade tissue expansion just after the expander implantation without taking care of a wound dehiscence that also prevented seromas. The prevention of seromas and haematomas, in their turn, reduced the infections and pressure sore rates above the expanders.

The commencement of tissue expansion immediately after implantation and the intensive filling technique did not cause any trophic alterations in the expanded tissues.

In plastic surgery psychosocial aspects play an important role and should not be underestimated. All patients want to get rid of their defect with minimal discomfort and within the shortest terms. Some moments during tissue expansion are disappointing, especially from the patient's point of view. Even if an expansion process has no complications, it considerably limits normal life and physical activity, especially if the expanders are located on exposed body sites, such as the face or head.

Defects of appearance are not life-threatening. Patients should not therefore suppose they are going to be "switched off" from their usual lives for 3-4 months (2-3 months for expansion plus of 2-4 weeks after the reconstructive op-

eration). It should be emphasized that a surgeon cannot guarantee the final outcome, because of the elevated risk of complications. If such complications occur (i.e. seroma, haematoma, infection, wound dehiscence), the expansion process lasts even longer and causes more discomfort (pain, daily bandagings, antibiotic therapy, repeated wound suturing, etc.). The new techniques have made it possible to reduce the risk of complications and to considerably reduce expansion time (from 2-3 to 1-1.5 months), thus significantly diminishing patient discomfort.

## Conclusions

Tissue expansion is an effective method in the treatment of various extensive post-burn scar deformities that makes it possible to increase the area of normal tissues available for reconstruction having a colour and texture similar to those of the defect area. Endoscopic expander implantation is preferable because of the reduction of expansion time and in-patient stay, and the prevention of complications. High-grade tissue expansion is started immediately after expander implantation and is maintained until sufficient tissue gain for reconstruction has been achieved. In reconstruction by means of expanded tissues adjacent to the defect, an incision is made on the opposite side and mobilization is effected towards an expander, with subsequent haemostasis that includes defective tissues on the flap. Pathological tissues are excised after removal of the expander and transposition of the expanded tissues on the defect. The new techniques effectively prevent complications, reduce expansion time by over a half, and minimize patient discomfort.

**RÉSUMÉ.** *Données générales.* Les désavantages de l'expansion tissulaire conventionnelle, une technique fréquemment utilisée dans la chirurgie reconstructive, sont la durée significative et le taux élevé des complications. Les Auteurs décrivent leur expérience du traitement en clinique de 329 patients traités avec cette méthode pendant la période 1987-2006. Avec la méthode ancienne, le temps moyen de l'expansion était de  $72 \pm 2$  jours ( $\pm$  DS) et le taux de complications locales était de 38,6%. Les Auteurs ont appliqué une nouvelle approche à cette méthode afin de réduire ses désavantages, c'est-à-dire l'implantation endoscopique des expandeurs, l'expansion intensive et une technique modifiée pour l'élévation d'un lambeau expansé. *Méthodes.* Vingt-sept patients traités à l'Institut de Chirurgie A.V. Vishnevsky entre 2001 et 2006 pour des séquelles cicatricielles post-brûlures ont reçu l'implantation endoscopique de 46 expandeurs de silicone dans diverses zones anatomiques du corps. L'expansion tissulaire à niveau élevé a été commencée immédiatement après l'implantation. L'élévation du lambeau reconstruit, y compris les tissus déficients du lambeau, a été effectuée et ensuite l'expandeur a été enlevé et les tissus expansés ont été transposés. *Résultats.* Utilisant ces techniques qui ont été perfectionnées, il a été possible de réduire le temps moyen de l'expansion de 72 jours jusqu'à 34 (moins que la moitié) et de réduire le taux de complications de 38,6% à 6,5%. *Conclusions.* Trois techniques - l'implantation endoscopique de l'expandeur, la technique accélérée de l'expansion tissulaire et l'élévation modifiée du lambeau expansé - ont permis aux Auteurs d'améliorer notamment les résultats du traitement des séquelles cicatricielles post-brûlure, avec l'emploi de la méthode de l'expansion tissulaire.

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