IS EXPANSION OF ARTIFICIAL DERMIS A RELIABLE RECONSTRUCTIVE OPTION?

Tsoutsos D.,^{1*} Zapantioti P.,¹ Kakagia D.,² Salmas M.,³ Marra A.,¹ Kyriopoulos E.¹

¹ Department of Plastic Surgery, Microsurgery, and Burns Unit, G. Gennimatas General State Hospital, Athens, Greece

² Department of Plastic and Reconstructive Surgery, Democritus University Hospital, Alexandroupolis, Greece

³ Department of Anatomy, University of Athens, Athens, Greece

SUMMARY. Reconstruction of full-thickness defects with the use of artificial dermis has been well established in the recent literature. The capacity of artificial dermis to expand over a period of years, months, or even days is described. Three such cases are reported. Two female patients, aged 21 and 30 years, with post-burn contractures of the chest with right breast hypoplasia and abdominal wall post-burn contractures respectively, and a 14-year-old male with a giant congenital naevus on the forearm, are presented. After excision of the contractures and the congenital naevus, the patients underwent staged reconstruction with the use of artificial dermal template and split-thickness skin autografts at monthly intervals. The 21-yr-old female also had a tissue expander placed submuscularly which six months later was replaced by a permanent silicone implant. Gradual expansion of artificial dermis was expanded over a period of months, until full-term pregnancy, while the third patient took years to achieve expansion naturally as he grew up. In conclusion, artificial dermis can be expanded over various periods of time (days to years), providing a reliable and safe alternative reconstructive method, particularly in areas where expansion is an absolute necessity for a good functional and aesthetic result.

Keywords: artificial dermis expansion, burn reconstruction, abdominal wall, pregnancy, breast

Introduction

Full-thickness burns of the anterior chest wall and abdomen that occur in childhood result in severely contracted scars that restrict chest and abdominal wall expansion. These scars, especially in young females of reproductive age, can lead to disfigurement, abnormal contour and malposition of the breast, breathing difficulties, and complications during pregnancy. Similar problems of disfigurement and decreased overall quality of life can also be caused by inadequate reconstruction of other full-thickness defects in adolescence. Various methods of reconstruction have been used so far. Here we report the use of expansion of the artificial dermal template Integra (Skin, Johnson & Johnson Medical, Division of Ethicon, Inc., Somerville, NJ) by surgical intervention (use of a tissue expander) and nonsurgical intervention (expansion due to pregnancy and age) and its results. All the patients presented with a satisfactory aesthetic and functional outcome regarding the shape, colour, contour, and elasticity of the reconstructed area.

Materials and methods

Between the years 2004 and 2009 three patients were reconstructed with expanded artificial dermis in the Department of Plastic Surgery Microsurgery and Burns Unit of the G. Gennimatas General State Hospital in Athens: a 21-yr-old female with post-burn contractures in the chest and right breast hypoplasia, a 30-yr-old female with postburn contractures in the torso, including the abdominal wall, and a 14-yr-old male with a giant congenital naevus on the forearm measuring 15 x 12 cm.

The first patient presented with post-burn contractures of the anterior chest wall and unilateral breast hypoplasia, due to thermal injury she had suffered at the age of 27 months, that were left to heal by secondary intention. Her main complaints were discomfort caused by deep breathing, due to reduced compliance of the thoracic wall, and breast disfigurement.

The patient was managed in three stages. The first stage consisted of the excision of the contractures and the submuscular insertion of a 450-ml anatomical tissue ex-

^{*} Corresponding author: Dimosthenis Tsoutsos, MD, PhD, Head of Department, Department of Plastic Surgery, Microsurgery, and Burns Unit, G. Gennimatas General State Hospital, 154 Mesogion Street, 11527 Athens, Greece. Tel.: 0030 2107709831; fax: 0030 2107709851; e-mail: tsoutsosdimos@yahoo.gr

Fig. 1a - Post-burn contractures of chest and right breast hypoplasia; 1b - Excision of the contractures, submuscular insertion of a 450-ml anatomical tissue expander, and coverage of the anterior chest wall with Integra artificial dermis; 1c - Post-operative results after 17 months. The patient presents with symmetrical breasts, natural inframammary fold, and projection of the reconstructed breast.

Fig. 2a - Post-burn contractures of the torso including the abdominal wall; 2b - Excision of the contractures and reconstruction with Integra artificial dermis of the anterior and 12 months later of the lower lateral abdominal wall; 2c - Abdominal skin and template naturally expanded during pregnancy without recurrence of contractures or presence of striae.



pander under the pectoralis major muscle. The expander, partly infiltrated with normal saline, and the anterior chest wall were covered by Integra artificial skin. One month later, the outer silicone layer of Integra was replaced by a split-thickness skin autograft and the expander was further infiltrated with normal saline. During the third stage, six months later and after overexpansion of the tissue expander had been completed, the expander was removed and a permanent 350 ml silicone implant was subsequently inserted (*Figs. 1a,b,c*).

The second patient presented with contracted post-burn scars of the torso, including the anterior and lateral abdominal and chest walls. The patient had suffered thermal burn injury at the age of three, which healed by secondary intention. The main symptoms were abdominal discomfort and difficulty in deep breathing, during exercise, due to reduced compliance of the thoracic and abdominal walls. Spirometric volumes were found to be slightly above minimum normal values for the patient's age and height (FEV10 = 2.25 lt, FVC = 2.60 lt, referring respectively to forced expired volume and forced vital capacity). The patient underwent staged reconstruction of the lateral abdominal wall. After removal of the contracted scars, the full-thickness cutaneous deficit was reconstructed by Integra in two stages (Figs. 2a,b,c): first the anterior abdominal wall was reconstructed and then, 12 months later, the lower lateral abdominal walls cm². At four-week intervals in each reconstructive stage the outer silicone layer was removed and the template was covered with thin autologous skin graft.

The third patient presented with a giant congenital naevus of the forearm (15 x 12 cm). His main concern was the aesthetic outcome after its removal. After excision of



Fig. 3a - Giant congenital naevus of the forearm (15 x 12 cm); 3b - Three years post-op. The recipient site maintains its elasticity, colour, and contour and resembles the surrounding normal skin; 3c - Seven years postoperatively the recipient site maintains its elasticity, colour and contour whereas the grafted dermal template has been naturally expanded (360 cm²).

the lesion, the full-thickness cutaneous deficit was also reconstructed by skin regeneration template in two stages (*Figs.* 3a,b,c), as described above.

Results

Recovery was uneventful in all three patients, who were given instructions about daily skin care with aloe vera cream after autologous skin grafting and removal of sutures.

Seventeen months after reconstruction the first patient presented with symmetrical breasts, stable breast contour with adequate projection of the reconstructed breast, and a natural inframammary fold. No recurrent contractures occurred. Expansion of artificial dermis was achieved with the use of a tissue expander over a period of three weeks, followed by a silicone implant, resulting in normal breast shape, size, and volume. The outcome was evaluated by the patient as very satisfactory.

The second patient, at her six-month follow-up, had a new spirometry that suggested improved breathing (FEV_{1.0} = 2.98 lt, FVC = 3.10 lt). The umbilico-symphyseal distance increased by 12 cm. One year post-operatively the patient was reviewed and found to be three months pregnant. The abdominal skin and the template were naturally and evenly expanded and the patient was followed up every month thereafter until delivery. The artificial dermis was naturally expanded within a period of nine months (*Fig.* 2c) and the patient had the opportunity to experience an uncomplicated full-term pregnancy. No stretch marks developed on the patient's abdominal skin during pregnancy. After delivery the patient's abdominal skin quality was similar to that of the surrounding skin.

The third patient presented at the yearly follow-up (*Fig.* 3b) with restored skin elasticity without any re-contracture appearing. At three years the recipient site maintains its elasticity, colour, and contour, resembling those of the surrounding normal skin. Expansion of the artificial dermis was achieved within a few years as the patient grew up.

Discussion

Management of full-thickness defects due to excision of lesions and post-burn contractures includes the use of skin grafts, flaps, and tissue expanders.^{1,2} These methods are often associated with donor site morbidity or are not accepted by patients as satisfactory treatment options owing to related aesthetic problems. Integra regeneration template has been successfully used to cover large burned surfaces of the trunk¹ and upper limb full-thickness cutaneous deficits due to as been successfully used to cover large burn surfaces of the trunk1 and upper limb full-thickness cutaneous deficits due to excision of extensive lesions.² It has been also been documented as being successfully expanded and used in combination with tissue expanders and implants in post-burn breast reconstruction.³

Tissue expansion of the post-burn breast is a wellrecognized modality of reconstruction since it has been suggested that expansion of the scarred chest wall soft tissues causes softening of the scars, which is beneficial for the final reconstruction.⁴⁶ It has been shown that mechanical force enhances keratinocyte growth and protein synthesis and alters cell morphology by stimulating signal transduction pathways, thus triggering cascades that lead to skin surface enhancement.⁶ However, most plastic surgeons prefer tissue expansion after the release of scars.^{68,9} In the patient presented here, release of the contractures preceded expansion of the artificial skin, as the limited skin envelope would have restricted the tissue expander.

The major problems caused by extensive post-burn scars on the chest and abdominal walls are breathing difficulties and discomfort.10 In female patients the prospective of normal abdominal skin stretching during full-term pregnancy is remote.^{6,11} Abdominal discomfort, pain, uterine displacement and scar breakdown may seriously complicate pregnancy during the last trimester.11 Even after scar excision and autologous skin grafting, breathing may be impaired by residual fibrosis and/or late graft contracture.10 Thin splitthickness skin grafts have a significantly higher tendency to secondary contraction than thicker skin grafts; the latter however, increase donor site morbidity. Transpositional flaps¹² and expanded reverse abdominoplasty¹³ have been suggested as alternative treatment modalities to skin grafting. However, the increased morbidity of these techniques compared to grafting is not to be ignored. In the patient described here, reconstruction with the use of artificial dermis and autologous skin graft improved breathing capacity, eliminated discomfort and disfigurement pregnancy.

For the third patient the psychological impact was of great importance, as the patient declined the use of a tissue expander though it had been proposed to him as an appropriate form of treatment. The necessity of repeated infiltrations and the look of the tissue expander on his forearm discouraged the patient from selecting this reconstructive method, while the result of the use of artificial dermis and thin skin grafting was rated by the patient as being very pleasing.

Conclusion

In conclusion, reconstruction with expanded artificial dermis provides elasticity and compliance of the reconstructed body surface and permits extensive expansion over various periods of time, improving the patients' overall quality of life. Expansion of artificial dermis should be considered a reliable and safe alternative reconstructive method, particularly in areas where tissue expansion is an absolute necessity for good functional and aesthetic results.

RÉSUMÉ. La littérature spécialisée offre une riche sélection des techniques actuellement disponibles pour réaliser la reconstruction, moyennant l'emploi du derme artificiel, des lésions provoquées par les brûlures à toute épaisseur. Les Auteurs, pour illustrer la capacité du derme artificiel de s'étendre pendant une période de plusieurs années ou bien de plusieurs mois, même de jours, prennent en considération trois cas. Deux femmes (âgées de 21 et 30 ans) présentaient une hypoplasie des contractures post-brûlure dans la zone de la paroi thoracique antérieure et de la mamelle unilatérale provoquées respectivement par une hypoplasie mammaire droite et par contractures post-brûlure de la paroi abdominale. Les Auteurs fournissent la description du troisième patient, un jeune homme de 14

ans qui présentait un naevus congénital géant à l'avant-bras. Après l'excision des contractures et du naevus congénital, les patients ont bénéficié de la reconstruction graduelle, à étapes successives, moyennant l'emploi d'un template dermique artificiel et des autogreffes cutanées à profondeur variable à intervalles mensuels. La patiente plus jeune a également bénéficié de l'application d'un extenseur de tissu placé en position rétropectorale, qui six mois plus tard a été remplacé par un implant permanent en silicone. L'expansion progressive du derme artificiel a permis de reconstruire, dans l'espace de trois semaines, un sein de forme et de taille naturelle et de volume normal. Quant à la deuxième patiente le temps pour l'expansion du derme artificiel s'est prolongé pour plusieurs mois, jusqu'au terme de sa grossesse de la patiente, tandis que le troisième patient a eu besoin de plusieurs années pour compléter l'expansion en manière naturelle, en arrivant à l'âge adulte. Nous pouvons conclure qu'il est possible de prolonger les temps d'expansion pour arriver à des périodes très variables (de jours, même de de plusieurs années), dans le but de fournir une méthode alternative de reconstruction fiable et sûre, notamment dans les zones où l'expansion est une nécessité absolue pour un bon résultat fonctionnel et esthétique.

Mots-clés: expansion du derme artificiel, reconstruction des brûlures, grossesse, sein

BIBLIOGRAPHY

- 1. Kritikos O, Tsoutsos D, Papadopoulos S et al.: The use of artificial skin in plastic surgery and burns. Acta Chir Plast, 48: 43-7, 2006.
- Gravvanis A, Kakagia D, Papadopoulos S et al.: Dermal skin template for the management of multiple cutaneous leiomynomas. J Cutan Med Surg, 13: 102-5. 2009.
- Tsoutsos D, Stratigos A, Gravvanis A et al.: Burned breast reconstruction by expanded artificial dermal substitute. J Burn Care Res, 28: 530-2, 2007.
- Slator RC, Wilson GR, Sharp DC.: Post-burn breast reconstruction: Tissue expansion prior to contracture release. Plast Reconstr Surg, 90: 668-74, 1992.
- Versaci AD, Balkovich ME, Goldstein SA: Breast reconstruction by tissue expansion for congenital and burn deformities. Ann Plast Surg, 16: 20-31, 1986.
- Kakagia D, Kyriopoulos E, Zapandioti P et al.: Natural expansion of artificial dermal template by successful full-term pregnancy. J Burn Care Res, Dec 29, 2011 (Epub ahead of print).
- Takei T, Mills I, Arai K et al.: Molecular basis for tissue expansion: Clinical implication for the surgeon. Plast Reconstr Surg, 102: 247-58, 1998.

- MacLennan SE, Wells MD, Neale HW: Reconstruction of the burned chest. Clin Plast Surg, 27: 113-9, 2000.
- Palao R, Gomez P, Huguet P.: Burned breast reconstructive surgery with Integra dermal substitute template. Br J Plast Surg, 56: 252-9, 2003.
- Webb JC, Back BR, Osler TM et al.: A pregnancy complicated by mature abdominal burning and its surgical solution: A case report. J Burn Care Rehabil, 16: 276-9, 1995.
- Haeseker B, Green MF: A complication in pregnancy due to severe burns in childhood. Br J Plast Surg, 34: 102-4, 1981.
- Haik J, Grabov-Nardini G, Goldan O et al.: Expanded reverse abdominoplasty for reconstruction of burns in the epigastric region and the inframammary fold in female patients. J Burn Care Res, 28: 849-53, 2007.
- Del Frari B, Pülzl P, Schoeller T et al.: Pregnancy as a tissue expander in the correction of a scar deformity. Am J Obstet Gynecol, 190: 579-80, 2004.

This paper was accepted on 29 December 2011.

