

# Reverse tissue expansion by liposuction deflation for revision of post-surgical thigh scars

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## ABSTRACT

Scars hypertrophy and widen when stretching mechanical forces are applied to resilient newly formed collagen before it reaches final maturity marring the final result of many surgical procedures and resulting in a clinical problem for many patients. Scar revision by surgical excision remains the traditional treatment for hypertrophic or widespread scars. It relies upon recruitment of local tissues for closure of the ensuing defect. Providing tension-free skin closure is the best option to avoid recurrence. Although tissue expansion procedure is a valuable and reliable technique for scar revision, it has its own disadvantages and potential complications. We describe an alternative method for scar revision that may be applicable in certain situations. Instead of expanding the soft tissues to make available additional skin, deflation by liposuction may be affected to relax the skin envelope thus indirectly providing additional skin for scar revision. We call this method 'reverse tissue expansion'.

**Key words:** Liposuction deflation • Reverse tissue expansion • Scar management • Scar revision

## INTRODUCTION

The skin is an organ in constant contact with the environment designed to adapt to stresses and strains. When injured, it consistently and rapidly repairs itself with necessary scar formation (1,2) the rate and quality of which varies

among individuals. Alterations in this process with deviation in the orderly pattern of healing, whether extrinsically or intrinsically derived, may result in the development of an abnormal scar (1). An overzealous healing response can create a raised nodule of fibrotic tissue, whereas 'pitted' and atrophic scars may result from inadequate replacement of deleted collagen fibres (3). Such textural changes are often permanent (3).

The aesthetic appearance of a scar is often the single most important criterion used by patients and physicians alike in judging surgical outcome (4). Ideal cosmetically acceptable scar is a nearly imperceptible soft fine line that is level with the skin, with good colour match, usually within or parallel to relaxed skin tension lines, and blends with the natural creases and folds (2,4). This fine scar may be the demarcating line between acceptable and unacceptable aesthetic results (1,5).

## Key Points

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- ideal cosmetically acceptable scar is a nearly imperceptible soft fine line that is level with the skin, with good colour match, usually within or parallel to relaxed skin tension lines, and blends with the natural creases and folds

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Sometimes, the final outcome falls short of these expectations (4).

Abnormal scars usually can be classified into four etiologic categories: traumatic, poorly designed, poorly healed, and disease-related (2). Scars with poor cosmetic results include those that are wide, raised, depressed, red, or pigmented, or those that transect natural creases and junctions (4). Depending on the type of abnormality, different techniques are used to improve the overall cosmetic appearance (4). Hypertrophic scars, however, are among the most common and frustrating problems after injury or surgery (5) and remain notoriously difficult to eradicate because of the high recurrence rates and the incidence of side effects associated with available treatment methods (1,5).

A variety of techniques, both surgical and nonsurgical, exists for treatment of unsightly scars (5,6). Surgical excision remains the traditional treatment for hypertrophic or widespread scars (1). It relies upon recruitment of local tissues for closure of the ensuing defect, and is best attempted on a mature scar, where surrounding tissues and the wound bed are not subject to exaggerated tension forces (6,7). Surgical strategies for scar revision include excision with linear closure, excision with split- or full-thickness skin grafting, Z-plasty, W-plasty, and if all other options fail, excision followed by flap coverage (2,4,8,9).

The ability to use local tissues depends on the nature of the anticipated defect and the availability of adjacent tissue for local advancement (10). Irrespectively, important principles for any scar revision are tension-free closure and wound edge eversion (7). Unfortunately, revision with tension-free closure is not possible for large widespread scars with insufficient surrounding tissue laxity (2). In such situations, tissue expansion or serial scar excision may be used to provide more tissue for advancement or to provide local flap coverage of revised scars (8). Serial excision is not an unpopular method of revising scars (6,11) and is possible due to stress relaxation (12). It has a major disadvantage of multiple procedures being necessary to render the desired scar reduction (11). Using conventional excision methods, the scar is partially excised and the adjacent skin advanced by undermining sufficiently. If more than two procedures are required, tissue expansion is useful as a

complementary tool to reduce the number of necessary excisions (2,6).

Tissue expansion with the use of internal tissue expanders is a reputable and reliable method for many forms of reconstruction (11,13). It is based on the principle that living tissues respond in a dynamic fashion to a mechanical stress that is placed on them (10) whereby tissue growth is induced with the application of increasing tension (14). Other techniques such as presuturing (11,15,16), towel clips (11,17), and skin-stretching devices (11,18–20) are also useful but are mainly applicable intraoperatively or a few days before definitive reconstruction. Lasheen *et al.* (21) successfully used external tissue expansion with negative pressure to overcome significant risk of complications. Their method nevertheless does not overcome the need for a specialised device (11). Traction-assisted dermatogenesis with Micropore (3M, St. Paul, MN) taping is an additional non-invasive method of tissue expansion recently described that is easy and cost effective to expand skin (11).

Although tissue expansion procedure is a valuable and reliable technique for scar revision, it has as with every surgical endeavour its own disadvantages and potential complications. At least two operations and multiple office visits are required during the expansion period (10,22,23). Tissue expansion with expanders has a significant major complication rate of approximately 25%. This complication rate may increase to above 40% in limbs (11,24,25). The most common complications are wound disruption and exposure of the implant, infection, haematoma or seroma, implant failure, pain, and skin ischaemia or necrosis (11,24–26). We describe an alternative method for scar revision that may be applicable in certain situations. Instead of expanding the soft tissues to make available additional skin, deflation by liposuction may be affected to relax the skin envelope thus indirectly providing additional skin for scar revision. We call this method 'reverse tissue expansion'.

## MATERIALS AND METHODS

Two young female patients presented with widespread scars on their lateral thighs for revision. Both have had orthopaedic surgical procedures several years earlier with subsequent

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- although tissue expansion procedure is a valuable and reliable technique for scar revision, it has as with every surgical endeavour its own disadvantages and potential complications
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scar revision by other surgeons consisting in elliptical excision and direct linear closure. In both patients, widespread scars developed in addition to stitch marks and gross thigh contour deformity and were 12 and 13 on the visual analogue scale (27,28). Both patients' scars were revised following liposuction deflation by elliptical excision and linear closure achieving a stable linear scar while improving thigh contour at the same time (Figures 1–6).

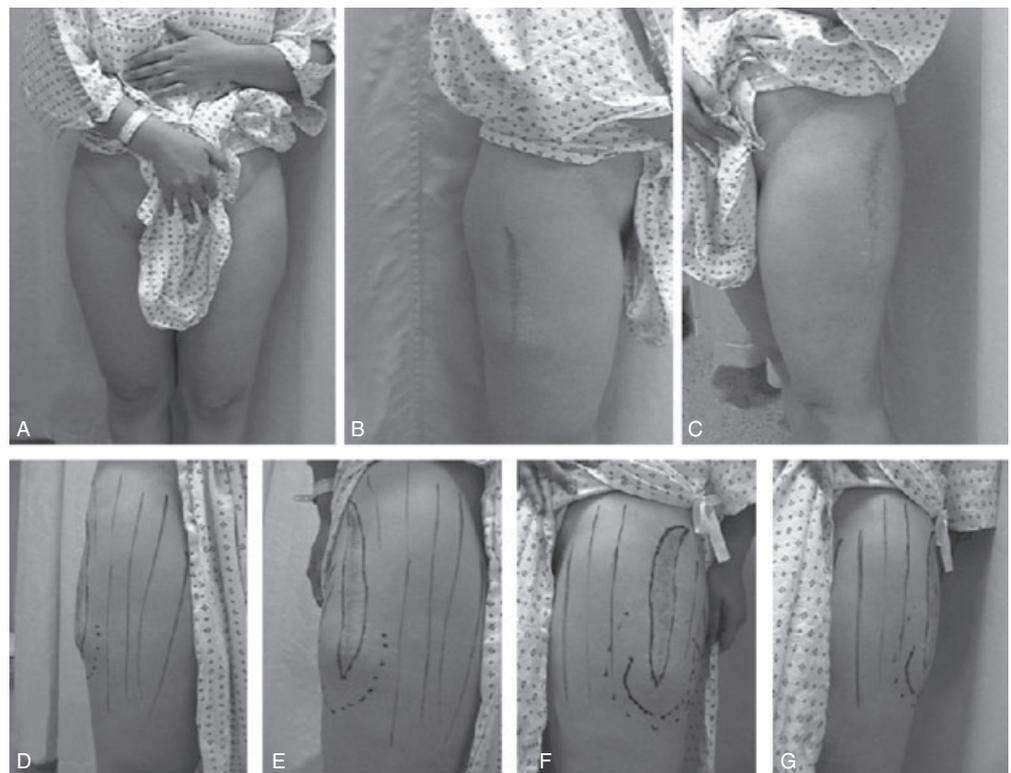
## DISCUSSION

A successful wound closure procedure is defined as a complete approximation of the wound margins with suturing of the skin (19). This, however, does not guarantee adequate scar evolution particularly if skin closure has been effected under tension such that some surgeons regard pathologic scarring as inevitable, regardless of surgical technique; others believe that their personal method of wound closure reduces it (29).

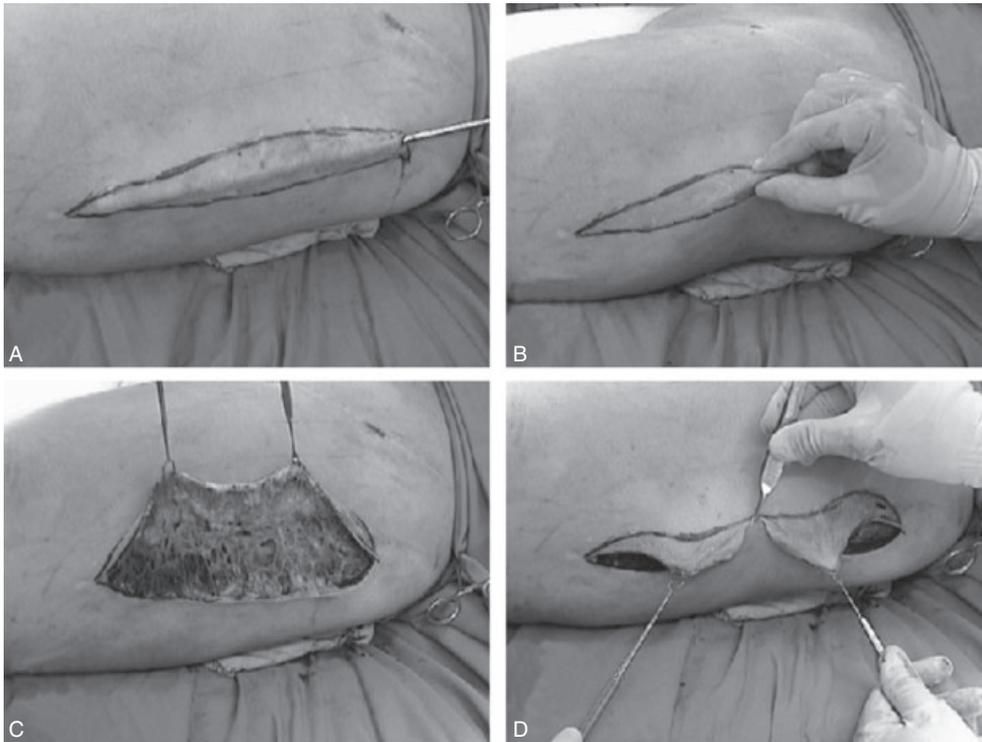
The skin has distinctive nonlinear viscoelastic properties and therefore can be stretched by applying mechanical forces (12,14,19). Skin

immediate extensibility is the product of its intrinsic elasticity. When stretched, the skin's convoluted collagen fibres straighten and realign parallel to one another (11,12). Further skin recruitment occurs secondary to mechanical creep which is elongation of skin with a constant load over time beyond intrinsic extensibility. With the passage of time stress relaxation enables the additional loading of skin to recruit even more tissue (11,12). These processes have been described as the vehicle harnessed for wound closure with pre-suturing, intraoperative tissue expansion, skin-stretching devices, and skin retraction with undermining (11,12). Although these processes help to close skin defects, they also generate opposing reciprocal mechanical forces that tend to pull the edges of the sutured wound apart.

Mechanical tension, plays a critical role in control of cell growth and function, and is critical for tissue remodelling in many tissues, including skin (14,30,31). Mechanical stress accelerates wound healing by producing stronger and more organised scars, however, at the expense of scar stretching (32).



**Figure 1.** (A, B, C) Patient with bilateral thigh scars following scar revision few years ago by another surgeon resulting in widespread scars with stitch marks and obvious contour deformity. (D, E, F, G) Markings for elliptical excision of scars and liposuction.



**Figure 2.** (A, B) Complete deflation by liposuction of the scar together with standard thigh liposuction. (C, D) Simple excision of the scar and simple approximation without neither tension nor undermining.

It is demonstrated that hypertrophic scarring occurs in areas of high tension with 'pull' in many directions or intermittent tension and is possibly initiated by lymphocytes but definitely related to a prolongation of the inflammatory process, with increased fibroblast activity and overabundant extracellular matrix secretion (33). A stretched scar results from increased tension in one axis only (34) probably initiated by neutrophils and their neutral proteases (34).

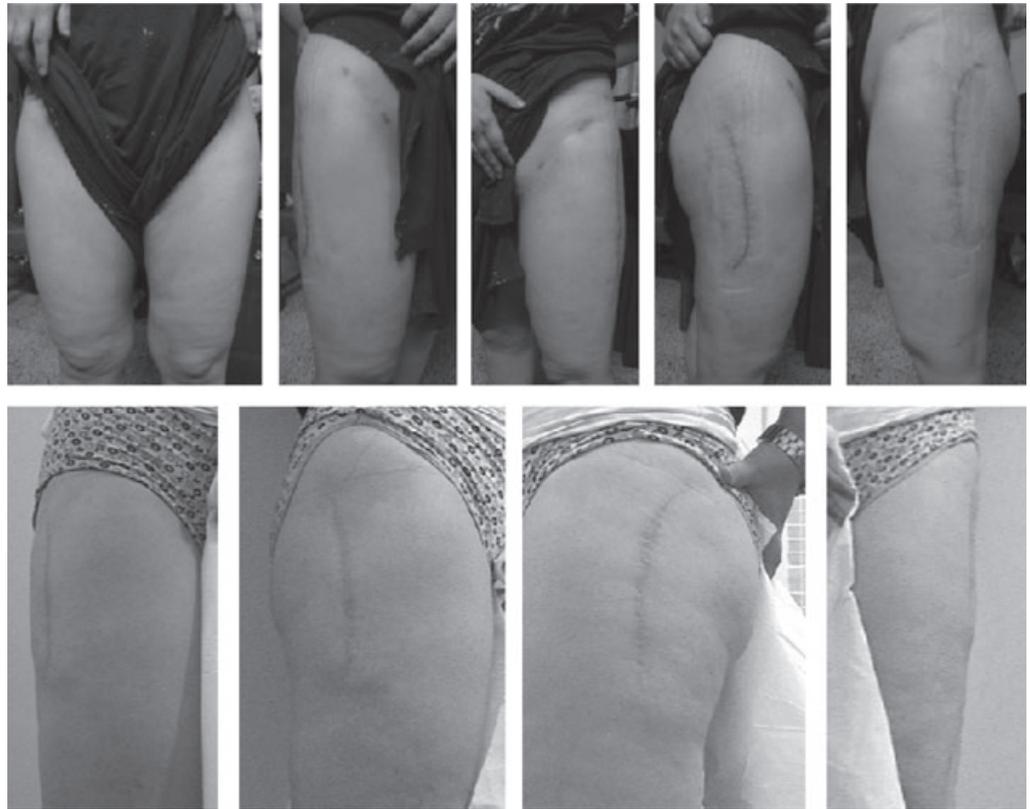
When sutured under a significant amount of tension, the skin tends to retract although not eventually back to its original condition before stretching (35). This is the stretch-back phenomenon which to a considerable extent reduces the benefits of fusiform excision and closure under tension (36). Studies on reduction of male baldness by serial excisions and closure under tension have shown that almost one third to one half of the excised bald area is lost due to the stretch-back, and that almost all the stretching occurs during the first 8 weeks following surgery (36). Moreover, it was also shown that although undermining significantly diminishes the tension on wound margins, increasing amount of tension while

advancing a scalp flap affects the compliance of the flaps in a nonlinear fashion demonstrating an exponential stress-strain characteristic of rapidly increasing stiffness (37).

Scars hypertrophy and widen when stretching mechanical forces are applied to resilient newly formed collagen before it reaches final maturity, a process that can take several months before being completed (38,39). Tensile distracting forces can be caused by factors such as muscle pull, elastic forces of adjacent skin, and external pressure (38,39). Widening of scars is thus mainly the result of mechanical influences on resilient and, as yet, immature collagen. This concept is probably validated by the outcome of healing wounds relative to the lines of Langer. These lines lie perpendicular to the tension vector of underlying muscular contraction (38,39). Anecdotal evidence suggests that incisions created parallel to skin tension lines rarely form abnormal scars. Moreover, abnormal scarring rarely develops in loosely skinned elderly patients (40). However, a wide variation in scar formation can be observed at different anatomical locations even when wounds have been closed using considerable tension. This suggests that the amount of

### Key Points

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**Figure 3.** (Upper row) Result at 2 months. (Lower row) One year and half after liposuction and scar revision with net improvement in scar appearance and thigh contour.

### Key Points

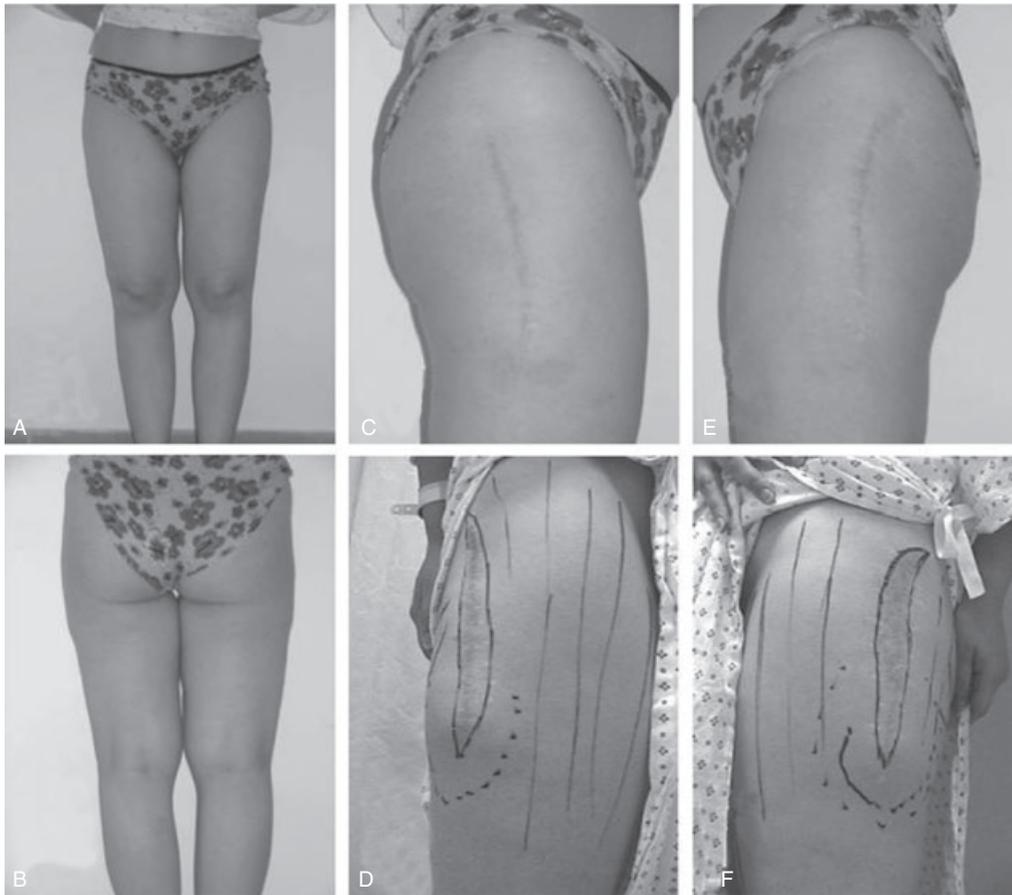
- scarring is determined not only by the amount of tension applied on the wound but, more importantly, by the viscoelastic properties of the skin at various locations
- immobilisation is a basic therapeutic principle in wound healing, common to the treatment of lesions of all kinds
- microporous tape has been reported to be a reliable way to support a scar

scarring is determined not only by the amount of tension applied on the wound but, more importantly, by the viscoelastic properties of the skin at various locations (35).

Widening of scars is a frustrating event that most if not all plastic surgeons have encountered (38). Even more frustrating is scar widening after re-excision which can subvert even the most meticulous wound closure techniques (7). Most plastic surgeons have frequently encountered this frustrating sequence of events: closing a wound in the neatest manner possible, meticulously apposing all layers, using thin, absorbable intradermal sutures, and within a few months having a wide, ugly scar appear (38). Different approaches have been advocated to tackle this problem. Corticosteroid injections, although more indicated for hypertrophic rather than stretched scars, are still quite popular, however, the final even more disfiguring outcome, consisting of thin, atrophic, telangiectatic, erythematous skin, has made many reluctant to use them. Other modalities include irradiation, ultrasound, and silicone applications, as well as many others,

but these treatment modalities do nothing to prevent or diminish the underlying distracting force which constitutes the main pathologic process (39). Millard (41) has described almost 40 years ago scar repair by the double-breasted vest principle to overcome the problem of tension. This technique was later revised using a small amount of existing scar tissue to hold the tension of the re-closure. A tongue of de-epithelialised scar is buried under a carefully dissected skin flap thus taking the tension off the surface of the skin (7,38).

Immobilisation is a basic therapeutic principle in wound healing, common to the treatment of lesions of all kinds. Casts, plates, and sutures minimise the negative effects of muscle tension on healing wounds, including skin lesions (39). Microporous tape has been reported to be a reliable way to support a scar (5,33). Repeated microtrauma caused by continuous displacement of injured tissue induces a prolonged inflammatory response and distortion of healing tissues before they achieve strength and maturity. Clinically, this would manifest as scar widening, hypertrophy, or both (39).



**Figure 4.** Patient 1: Final stable result of linear scar revision with at 3 years despite 8 kg weight gain. (A, B) Pleasant thighs contour. (C, E) Right and left thigh scars with (D, F) preoperative scars shown for comparison. Scar excision was 5 cm in the mid portion.

Anecdotal techniques of annulling muscle contraction by putting the face in a bandage mask for 3 months have been described but were poorly tolerated by the patients (39). More recently botulinum toxin injections simultaneous with scar revision surgery of the face has been described to induce temporary paralysis of the underlying muscles effectively minimising tension on the healing wound edges (39).

Providing tension-free skin closure remains the best option to avoid recurrence of widespread or hypertrophic scars following surgical revision. Tissue expansion is invaluable in that regard. 'Natural' expansion of abdominal skin in conjunction with pregnancy as an internal autologous endogenous expander has been previously described as extremely useful for ventral hernia repair as well as for scar revision (42–45). Similarly, lipodystrophy and obesity produce natural expansion. Removal of excess fat by liposuction will

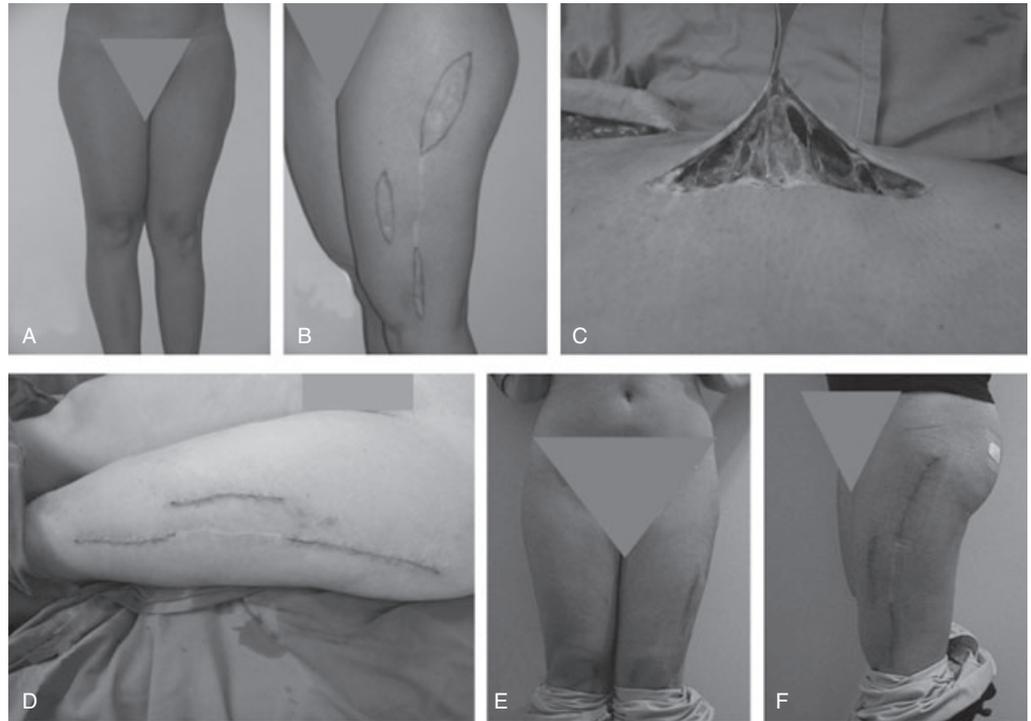
deflate the tissues and provide relaxed skin for scar revision.

Skin is an envelope confining a given body volume in a ratio surface/volume (S/V). For scar revision tension-free skin closure S/V ratio must be increased at least to compensate for the scar surface that must be excised if not more. This can be achieved either by increasing S by expansion or decreasing V by 'reverse expansion' through liposuction (Figure 7). Liposuction with deflation of adjacent tissues reduces the volume and provides discontinuous undermining that will allow flap mobilisation and advancement without undermining (46–49) facilitating wound closure without tension.

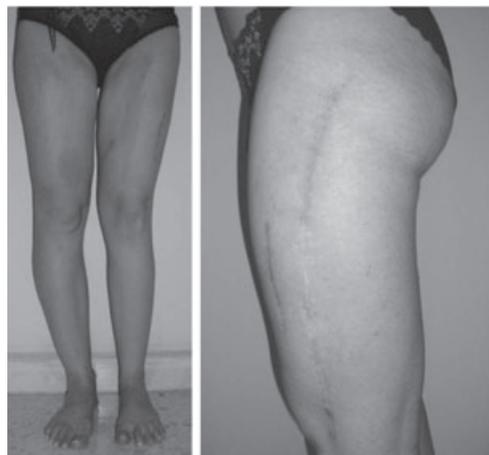
One major drawback of this technique, although, is that preoperative planning using exact measurements similar to standard tissue expansion is not applicable. Pinch test and clinical judgment are required to determine if

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- one major drawback of this technique, is that preoperative planning using exact measurements similar to standard tissue expansion is not applicable
- pinch test and clinical judgment are required to determine if a wide scar may be revised and closed primarily or additional skin may be required to allow closure with minimal tension



**Figure 5.** Patient 2: (A, B) Patient with lateral left thigh widespread scars and contour deformity following previous scar revision. (C) Complete scar deflation with bilateral standard thigh liposuction. (D) Immediate postoperative result following revision of the widespread scar segments only. (E, F) Result at 2 months.



**Figure 6.** Patient 2: Result at 7 months with net improvement in thighs contour and symmetry and stable linear scars despite wide excision superiorly. Marks on anterior thighs are secondary to irritation and recent prolonged sun exposure at the beach.

a wide scar may be revised and closed primarily or additional skin may be required to allow closure with minimal tension. In that case, additional skin may be provided either with standard expansion or with liposuction provided that latter is indicated. As with other patients presenting for liposuction,

surgical decision is made using clinical and aesthetic parameters. MRI or ultrasound, useful as research tools, are not routinely used to determine thickness of the fatty layer as these tests are clinically not relevant for routine liposuction and will result in additional costs to the patient. Liposuction is performed with the tumescent technique and is aimed at improving the patient's contour. Relaxed skin may be determined thereafter with the pinch test and is a welcomed addition that may be used secondarily for scar revision. Wound closure is performed in layers. The deep fascia is closed first with interrupted sutures followed by a running subcuticular suture. Only resorbable sutures are used, 2-0 Vicryl® (Polyglactin 910) for the fascia and 4-0 Monocryl® (Poliglecaprone 25) [Ethicon, Inc. (Johnson & Johnson Intl) St-Stevens-Woluwe, Belgium] for the skin. A simple semi-permeable dressing is then applied and the patient fitted with the regular liposuction compression garment for 6 weeks. Moist exposed burn ointment MEBO® (Gulf Pharmaceutical Industries, Ras Al Kahimah, UAE) previously shown to improve scar quality is also applied twice daily

during this period (50,51). Although some surgeons do insert drains following liposuction, we usually do not and we did not feel that drains were necessary even after scar revision.

Another drawback of combining liposuction with scar revision may be the theoretical compilation of complications. In fact, mild to moderate liposuction (not more than 1.5–2 l) is a well-standardised procedure performed routinely with a low complication rate; when combined with scar revision it should, theoretically as well, reduce the complication rate of scar revision performed under tension. Compared to the high complication rate of tissue expansion in the lower extremity, combined liposuction and scar revision has probably a lower complication rate and is definitely a more convenient one-stage procedure. It is also a more rewarding procedure to the patient that will benefit from an immediately apparent better contour.

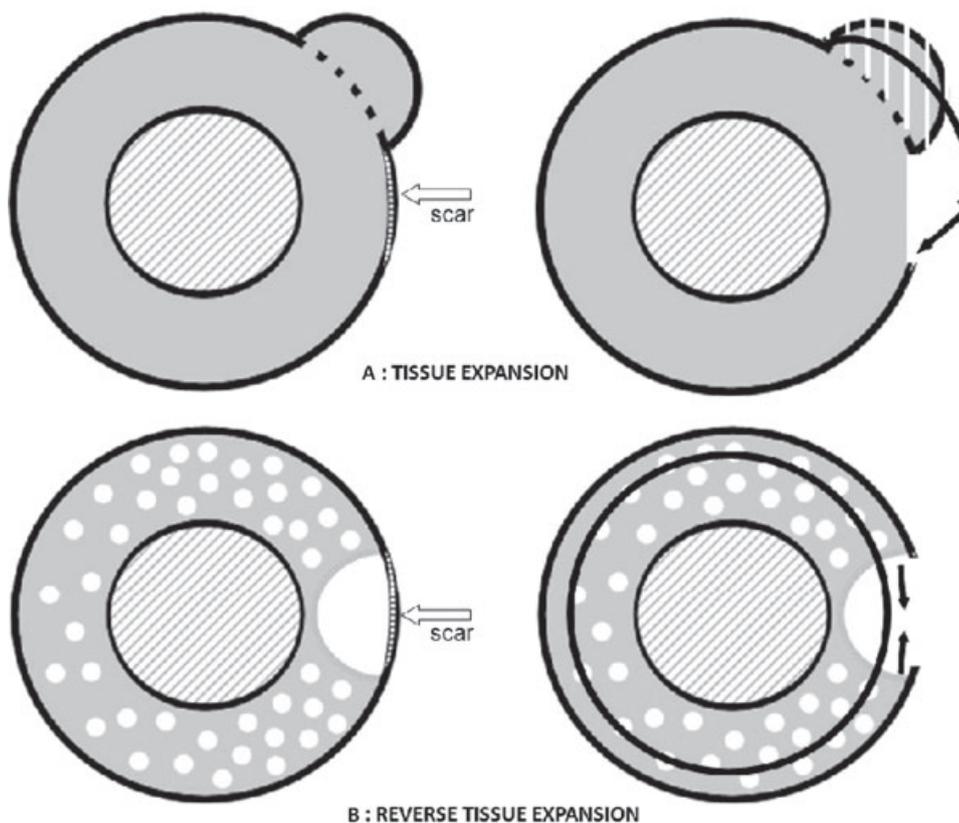
## CONCLUSION

Pathologic scarring marks the final result of many surgical procedures and remains a clinical problem for many patients (52). Scars on the trunk and extremities often hypertrophy and spread with very noticeable 'track' marks (4). Unsightly hypertrophic and widespread scars may cause functional and cosmetic deformities, discomfort, and psychological stress (7). Scar revision is a well-established procedure and is indicated in certain situations for cosmetic and functional reasons (53). A successful scar revision can dramatically improve a patient's quality of life (2). Unfortunately, achievement of satisfying long-term results may present a real challenge (54).

The surgery and management of scars is a protracted and staged process (55). Scar revision requires planning and preoperative counselling regarding recurrence risks, particularly for keloid-prone patients (1). Preparation of the skin through hygienic measures,

## Key Points

- scar revision requires planning and preoperative counselling regarding recurrence risks, particularly for keloid-prone patients



**Figure 7.** (A) Tissue expansion:  $S/V$  ratio increased by increasing  $S$  (inner circle: thigh muscle and bony mass circumference). Outer circle: thigh circumference). The increase in  $S$  should be at least 1.2 to 1.5 times the width of the scar to be excised. (B) Reverse tissue expansion:  $S/V$  ratio increased by decreasing  $V$  (white dots represent tunnelling by liposuction). Fat underlying the scar is completely aspirated resulting in total deflation of the area allowing skin approximation (represented by the middle circle on the right) after scar excision with no tension.

## Key Points

- preparation of the skin through hygienic measures, scar softening (if indicated) with steroids, massage and pressure dressings, skilled execution of the surgical plan, and thorough post-operative wound care cannot be over emphasised to achieve favourable results
- it is important to realize that in scar revision there are factors beyond the surgeon's control and factors certainly under his control the most important of which is to achieve skin closure with no tension
- the decision to revise a scar must be reached by patient and surgeon, with realistic expectations and the end-point clearly established
- in certain situations, reverse tissue expansion by liposuction may be highly beneficial and even desirable
- it not only provides tension-free wound closure but also achieves improvement in body contour which will be much more gratifying to the patient than the actual improvement in scar quality.

scar softening (if indicated) with steroids, massage and pressure dressings, skilled execution of the surgical plan, and thorough postoperative wound care cannot be overemphasised to achieve favourable results (55). Although 'there is no generic approach to timing or technique in scar revision', the decision of how and when to intervene with a scar revision lies between the patient and the physician, with the latter providing strong and accurate guidance (56). Conservative timing allowing the natural process of healing is always to be primarily considered (56).

It is important to realise that in scar revision there are factors beyond the surgeon's control and factors certainly under his control (56,57) the most important of which is to achieve skin closure with no tension. It must be realised also that improvement is not feasible with all scars; expectations must be tempered and realistic goals set (53). The decision to revise a scar must be reached by patient and surgeon, with realistic expectations and the end-point clearly established. The simplest and most direct approach should then be taken to reach this goal (53). In certain situations, reverse tissue expansion by liposuction may be highly beneficial and even desirable. It not only provides tension-free wound closure but also achieves improvement in body contour which will be much more gratifying to the patient than the actual improvement in scar quality.

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