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The Use of Foley Catheter for Immediate Intraoperative Tissue Expansion

Arthi Kruavit, MD
Vivat Visuthikosol, MD
Division of Plastic and Maxillofacial Surgery, Department of Surgery, Ramathibodi Hospital, Bangkok 10400, Thailand

Abstract

Background: **The two-stage technique of tissue expansion is well-accepted modality for increasing available local skin flap with the same colour, texture, and sensation for defect closure. Immediate intraoperative tissue expansion with several stress-load cycles is a technique based upon the same principle of traditional chronic tissue expansion. The use of Foley catheter as a tissue expander for immediate intraoperative tissue expansion has been previously reported.**

Objective: **To demonstrate the use of Foley catheter for immediate intraoperative tissue expansion with only one stress-load cycle.**

Materials and Methods: **Twelve patients, ages ranged from 7-52 years, underwent immediate intraoperative tissue expansion for closure of small skin defect in which simple primary closure was not possible despite proper undermining. One to four 30 ml Foley catheters were used with one stress-load cycle of 20-40 ml saline inflation. Six procedures were for scar revisions, five for closure of skin defects following removal of pigmented lesions (in five patients), one for closure of traumatic leg wound defect and one for lengthening of lower lip.**

Results: **All twelve skin defects were closed by the expanded skin flaps. Advancement flap was the most common flap (10/12) used for reconstruction. There were no skin necrosis, wound dehiscence or infection. The postoperative results were satisfactory including the lengthening of the lower lip. However, some patients needed scar revisions to obtain better aesthetic results.**

Conclusions: **The technique of using Foley catheter for immediate intraoperative tissue expansion with single stress-load cycle for 30 minutes is safe and can be performed easily under local anaesthesia. This is a nice technique for a surgeon to keep in mind.**

The concept of tissue expansion, based on the skin's natural ability to stretch in response to an underlying force, was first described in 1957 by Neumann[1] for reconstruction of a traumatic partial ear amputation. He placed a rubber balloon in the subcutaneous plane beneath the post auricular skin and serially inflated it with air. Despite his success, this technique was ignored for two decades until Radovan,[2,3] beginning in 1976, utilized a similar technique for breast reconstruction. Radovan's "expander" was a medical grade silicone device with a remote injection port for serial saline injections. Austad and Rose,[4] working independently, developed an implant that utilized a sodium chloride osmotic gradient to achieve gradual tissue expansion without serial injections. Because of longer expansion times (roughly double the 6 weeks needed with the Radovan device) and the risk of skin necrosis with implant rupture, the Radovan type expander is currently the device of choice. The two-stage tissue expansion has been advanced and employed for reconstruction of most areas of the body including the scalp, face, neck, breast, anterior and

posterior trunk, and the upper and lower extremities. Numerous reports of chronic tissue expansion (or controlled tissue expansion) have appeared in the literatures detailing the refinement of both the surgical technique and the expander, and also the results and complications.[5-19]

Intraoperative tissue expansion is another technique based on the principle of "tissue creep" initially described in 1977 by Gibson,[20] and the knowledge gained from chronic tissue expansion. Much of the pioneering work in this area was done by Sasaki[21] who called it "intraoperative sustained limited expansion (ISLE)". The single-stage technique employed the same expander as that used for chronic tissue expansion. The expander is inserted, inflated, and deflated with saline or air for several stress-load cycles of 2 to 3 minutes at the time of surgery totalling 15 to 30 minutes replacing several weeks of serial injections. Each successive cycle allows for further inflation of the expander. This concept of loaded cycling had been previously employed clinically using skin hooks to stretch the nasal skin and decrease wound closure tension at the nasal tip.[22] In 1988, Stein[23] advocated the use of Foley catheter for immediate expansion in place of the more expensive silastic expanders. He wrote a letter to the editor "...Most emergency rooms, surgical outpatient centers, and office surgical suites do not stock a supply of tissue expanders. A Foley catheter or multiple Foley catheters with 30 ml balloons are readily available for such use and are beneficial in primary closure of difficult wounds." The authors have had the experience of using tissue expanders at Ramathibodi Hospital since 1987. We also modified the technique and advocated the reused tissue expanders by autoclaving sterilization in order to save cost as the tissue expander is relatively expensive.[24-27] We have learnt from our experience that during serial injection of saline at each session, the blanching effect of skin perfusion at the expanded area will determine the maximum volume of saline injected. If it is pale with no capillary refill at all after half an hour, some of the normal saline solutions will be aspriated until capillary refill returns. In this clinical condition, all expanded skin flaps will always survive and more fluid injection could be added in the next session in the same manner. The purpose of this paper is to present the technique for immediate intraoperative tissue expansion using 30 ml Foley catheter(s) for only one stress-load cycle, rather than several as described above, to reconstruct small skin defects that could not be closed primarily with ease in spite of proper undermining.

Materials and Methods

Patients

During from 1991-2002, 12 patients underwent immediate intraoperative tissue expansion for one-stage correction of small benign skin lesions of the head and neck region as well as the back, the upper extremity, and the lower extremity. There were 8 males and 4 females, ages ranging from 7-52 years.

Six patients were operated on under local anesthesia, one patient under regional anesthesia. Only five procedures were performed under general anesthesia for those who did not cooperate with local anesthesia. Scar revisions were performed in six patients while closure of skin defects following removal of pigmented skin lesions were performed in four patients (one 7-year-old girl had two congenital melanocytic nevi removed in one setting procedure), closure of traumatic wound of the leg in a 52-year-old man, and lengthening of the lower lip in a 15-year-old body who had psychological problem. The latter patient bit his lower lip with his upper teeth, causing chronic ulcer from which a scar contracture of the lower lip developed when the wound healed.

Technique

The technique of immediate intraoperative tissue expansion with Foley catheter (Figure 1) is simple and easy. It can be performed under local anesthesia, sometimes, as an out-patient basis. Foley catheters are always available in the hospitals. They come in various sizes and are usually measured by the French system which refers to the outside diameter of the catheter and has no bearing on the balloon size. In the French system each unit is quivalent to 0.33 mm. Thus, a 12 French catheter has an outside diameter of 3.96 mm. Additionally, each catheter has an inflatable balloon attached to its tip. Each balloon is labeled as either 5cc, 15, 30, 75 ml etc. These are not definitive volumes, since each balloon can easily hold at least two times the volume of fluid that is indicated without rupturing. For intraoperative tissue expansion, it is the balloon portion of the Foley catehter that is important, not the

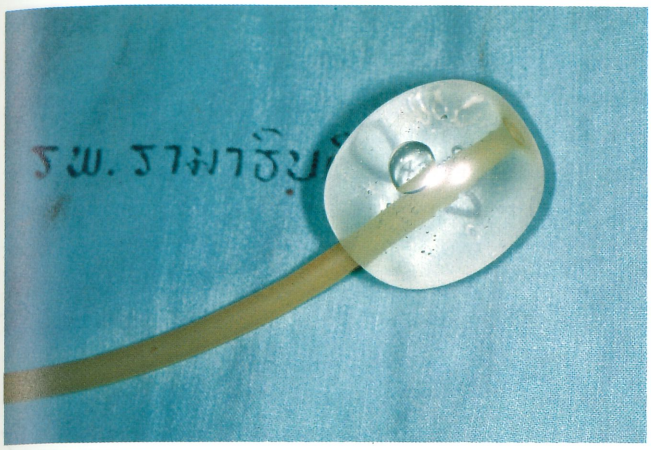


Fig. 1 The distal end of a 30cc Foley catheter. Its tip was cut and the balloon was expanded from instillation of saline solution.

catheter itself. If the post-operative result is not perfect, with stretching of the scar, scar revision can always be performed at a later date to improve the aesthetic result.

Following the aseptic and antiseptic technique, apart from general or regional anaesthesia, a local infiltration with lidocaine (1%) containing epinephrine is used for local anaesthesia. Vasoconstrictive effect of the epinephrine is essential for bleeding control and has not been associated with flap ischemia. Prophylactic antibiotic is employed to prevent infection. The Foley catheter(s) may be placed and expansion may be performed either before or after excision of the lesion. When the Foley catheter is placed before excision, a short incision is made close to the benign lesion or on the lesion (not on the normal skin). The surrounding skin flap is undermined from this incision, to the area to be expanded. The subcutaneous plane is used for extremities, back, head and neck regions except the forehead area where undermining is done under the frontalis muscle. One to four 30 ml Foley catheters are then inserted through the tunnel into the pocket. The tip of the Foley catheter may or may not be cut. Inflation of the balloon with sterile normal saline solution or air is carried out until the skin overlying the balloon becomes blanching and tense. In this clinical condition, there is no capillary refill on the blanching skin. After half an hour, the balloon is deflated and removed, and capillary refill now returns. The expansion is done only once and the lesion is excised. Meticulous hemostasis is important to prevent hematoma formation, however, a postoperative drainage system is sometimes essential. The expanded skin is used to close the defect in a layered closure without tension by the evidence of capillary refill at the wound margins and dermal bleeding at the edge of the expanded skin flap which indicate skin flap viability. If the lesion is excised before immediate intraoperative expansion, the undermining is performed in the same manner; but care is taken to prevent extrusion of the balloon during maximum inflation. This may be dealt with in one of several ways. Towel clips or other similar clamps can be used to hold the wound margins in place. The digits can also be used to simply hold the balloon in position. The author's prefered technique is to do extensive undermining for adequate accommodation of the balloon. It should be advised that a malignant skin lesion be widely excised before intraoperative skin expansion.

Results

Two Foley catheters were used in 11 lesions, one catheter in one lesion, and four catheters in one lesion. The saline solution inflated for each 30 ml balloon varied from 20-40 ml. The results confirmed the overall efficacy of the procedure with one single stress-load cycle. All wounds healed following layered closure without tension with no evidence of wound infection, wound disruption, or skin necrosis. Five patients needed further scar revision for better aesthetic results. Three forms of flap reconstruction following immediate expansion were used: advancement flap (10), transposition flap (1), and rotation flap (1). No flap was required in one patient who had lower lip lengthening. Further details are shown in Table 1.

Table 1 Method of flap closure in 12 patients (13 lesions). A 7-year-old girl underwent removal of two congenital melanocytic nevi in one setting.

Area of Defect	Lesion	AF	TF	RF	L
Head & Neck	6	3	1	1	1
Upper Extremity	5	5	0	0	0
Lower Extremity	1	1	0	0	0
Back	1	1	0	0	0
Total	**13**	**10**	**1**	**1**	**1**

(AF = Advancement Flap, TF = Transposition Flap, RF = Rotation Flap, L = Lengthening)

Illustrated Cases

Case 1 (Figure 2)

A 15-year-old girl sustained a car accident and developed a nasty scar at the forehead. She underwent scar revision a year ago but the result was not satisfactory. She was referred to us for scar revision. The lesion was 3.5×4.0 cm. After the forehead skin flap was undermined under the frontalis muscle, two 30 ml Foley catheters were used for immediate intraoperative skin expansion under general anesthesia with local infiltration of 1% lidocaine containing epinephrine. Following 30cc of saline injection to each balloon for 30 minutes, deflation, and removal of the balloons, the skin flaps were transposed for direct closure of the defect. She was satisfied with the result, however, long term follow-up is needed and a better aesthetic result can be obtained by simple scar revision procedure.

Case 2 (Figure 3)

A 25-year-old man came to the hospital for correction of the scar of the grafted skin on his left forearm measuring 5 × 6 cm in size. He underwent removal of a decorative tattoo and the excised defect was grafted with skin harvested from the left thigh. However, he was not happy with the scar of the grafted skin and wanted to have a linear scar instead. Following local infiltration with 1% lidocaine containing epinephrine, two 30 ml Foley catheters were used for immediate intraoperative skin expansion by single stress-load cycle of 30 minutes. Forty cubic millilitre of saline was inflated to each balloon. After the immediate expansion, elliptical excision of the grafted skin was done and direct closure without tension was successfully achieved. However, stretchning scar developed some months after the operation and simple scar revision was performed under local anesthesia. The final postoperative result was satisfactory.

Case 3 (Figure 4)

A 52-year-old man sustained a motorcycle accident and had compound fracture of the left tibia. The fracture was reduced and immobilised with a plate and screws. Unfortunately, minor wound infection



Fig. 2 Photographs of Case 1
A The scar at forehead measured about 3.5 x 4 cm. This scar had been revised once but the result was not satisfactory. Transverse alopecia scar in the frontal hairline was a result of previous scar revision procedure.
B Two 30 ml Foley catheters were used for immediate intraoperative forehead skin expansion by single stress-load cycle for 30 minutes. The blanching appearance with no capillary refill on the expanded skin area could be visualised.
C The appearance at two months after the operation.

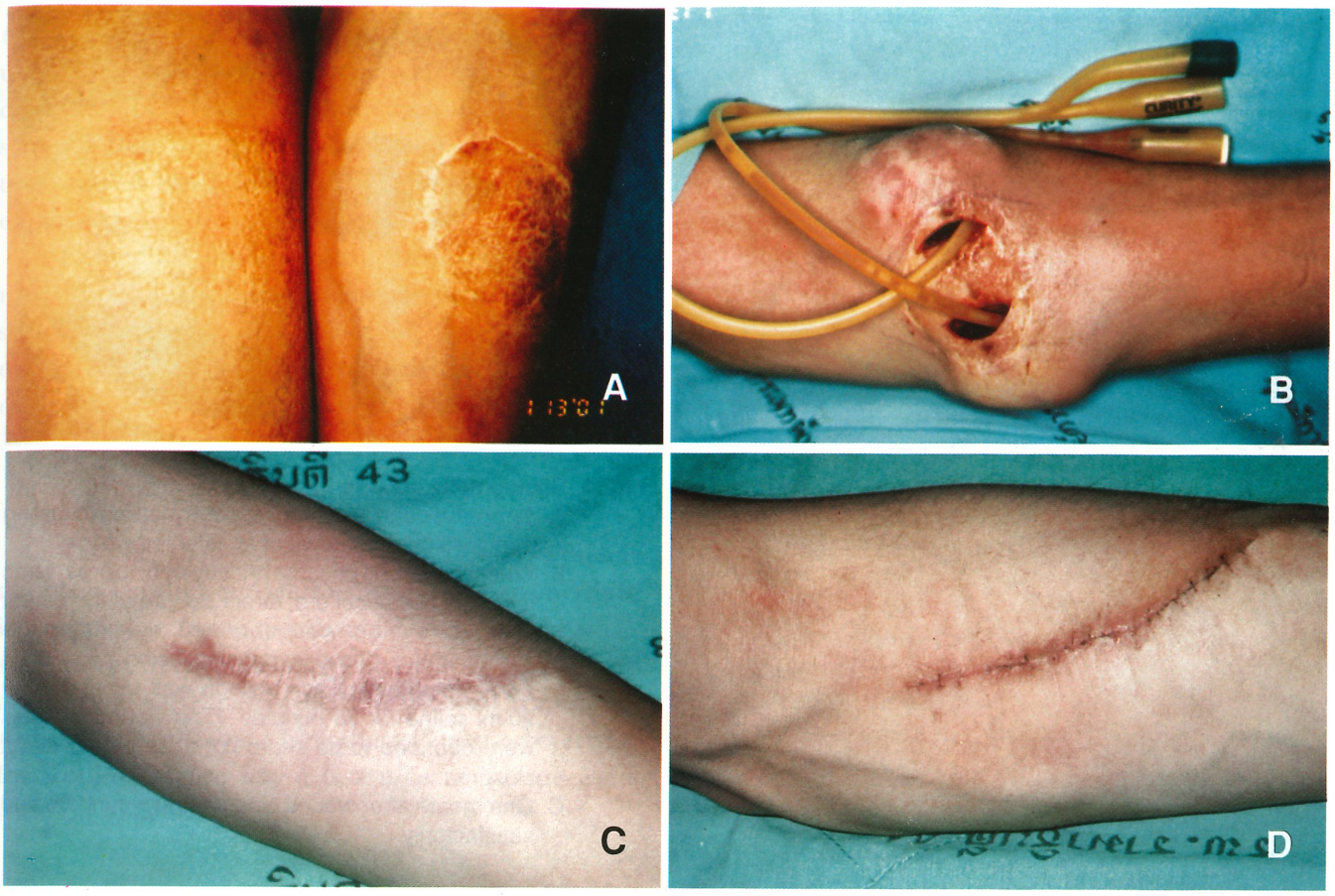


Fig. 3 Photographs of Case 2
A A scar at left forearm from skin grafting procedure hearvested from left thigh following removal of a decorative tattoo.
B Immediate intraoperative tissue expansion before removal of the grafted skin scar was performed using two 30 ml Foley catheters. Each balloon was injected with 40cc saline for 30 minutes.
C The appearance of the surgical scar at four months following elliptical excision was not still acceptable because stretching scar developed.
D Following simple scar revision, the aesthetic result was improved.

developed a few days after the operation. Proper drainage of wound with appropriate antibiotics were administered to treat local infection. Ten days later when the wound culture revealed no organisms, direct wound closure was carried out under general anesthesia using two 30 ml Foley catheters. Twenty millilitres of saline was injected into each balloon for 30 minutes. Following deflation and removal of the balloons, direct closure without tension was achieved. One month postoperatively, the wound had healed satisfactorily.

Discussion

As fas as the reconstructive surgery is concerned, there are multiple variables that affect the ease of closure of any single wound. Each patient and defect must be individualized, the closure must be carefully planned in a knowledgeable manner. Often the simplest closure without tension is ideal and yields the best result. Each technique depends on the surgeon's experience, expertise, and also his/her preference; however, undermining of the surrounding skin flaps is a basic technique to help create direct wound closure without tension. Borrowing tissue through expansion from adjacent areas has proved to be of benefit in surgical reconstruction. Apart from traditional chronic tissue expansion using silicone expander, immediate intraoperative tissue expansion is based on a sound theory. It has already been proved to be useful in a multitude of surgical procedures.[21,28-30] The actual amount of skin that is increased during immediate intraoperative tissue expansion was 0.5 to 2.5 cm

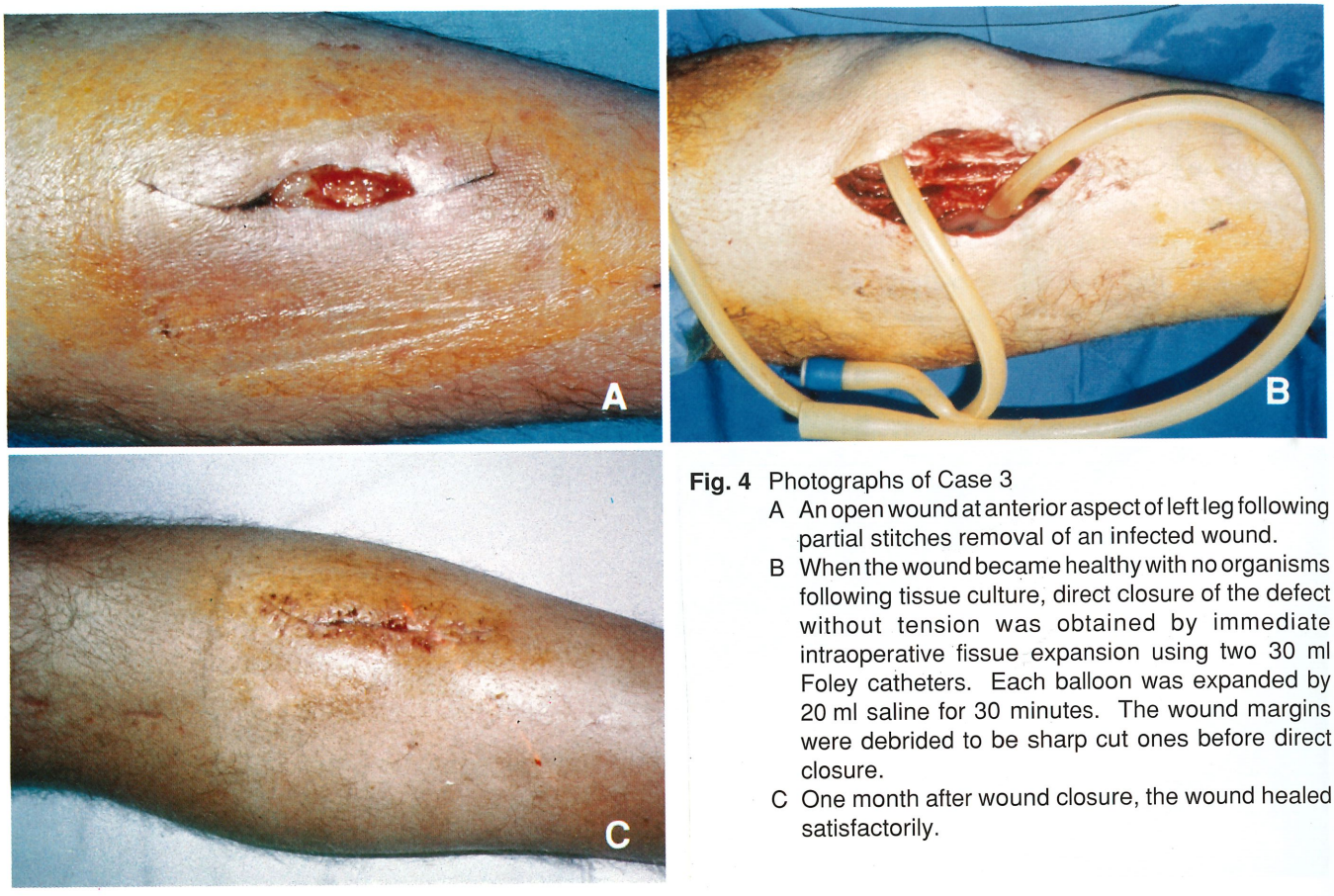


Fig. 4 Photographs of Case 3
A An open wound at anterior aspect of left leg following partial stitches removal of an infected wound.
B When the wound became healthy with no organisms following tissue culture, direct closure of the defect without tension was obtained by immediate intraoperative fissue expansion using two 30 ml Foley catheters. Each balloon was expanded by 20 ml saline for 30 minutes. The wound margins were debrided to be sharp cut ones before direct closure.
C One month after wound closure, the wound healed satisfactorily.

depending on the site of expansion.[21] The ability of the skin to stretch and increase in surface area immediately is partly explained by the phenomenon termed "creep"[20,31] which is based on four factors: (1) displacement of fluid and ground substances leads to relative dehydration of tissue; (2) random position collagen fibres realign in a parallel fasion; (3) micro-fragmentation of elastic fibres; and (4) adjacent tissue migrates into the field from the stretching forces. The support for immediate intraoperative tissue expansion is not unanimous, and some authors have demonstrated that this technique is not effective in reducing wound closure tension and that the technique of extensive undermining alone is one of the most important steps in wound repair that provides the ultimate goal.[32]

Complications during chronic tissue expansion ranged from 7 to 43 per cent, depending on the surgeon's experience and location of expansion. Complications include infection, hematoma, seroma, skin necrosis, flap failure, exposure or extrusion of the expander or reservoir (port), wound dehiscence, nerve dysfunction, pain, and bone resorption.[5,6,12,15,27] Complications resulting from immediate intraoperative tissue expansion, reported in 120 cases by Sasaki,[21] were lowest in the head and neck region (2%) and highest in the lower extremity (26%). Our experiences have shown that immediate intraoperative skin expansion using one to four 30 ml Foley catheters with one single stress-load cycle for 30 minutes is helpful for primary closure of 12 benign skin lesions and lengthening of one lip scar contracture without any complications. Thirty minutes are long enough for meticulous hemostasis of the undermined area (expanded area) by pressure dressing, however, drains were sometimes used postoperatively to prevent hematoma or seroma formation. This does not mean that one stress-load cycle is better than several stress-load cycles. Yet, we conclude that one single stress-load cycle for 30 minutes is a safe technique for immediate intraoperative tissue expansion causing no expanded skin flap necrosis. The most important step of direct wound closure to prevent marginal flap ischemia or necrosis is to observe dermal bleeding at the edge of the skin flap. The use of local flaps

(transposition flap and rotation flap) and extensive undermining (advance-ment flap) are essential to help close the wound defect without tension. It should be stressed that the quantity of tissue gain from this technique is much less than seen with chronic tissue expansion.

Immediate intraoperative tissue expansion has many applications. Breast augmentation, rhytidectomy, scalp, nose, cleft palate, lower lid, upper and lower extremities have all been facilitated by tissue expanders[28,33] or Foley catheters. [34-37]

Conclusion

The technique of using Foley catheter, which is always available in all hospitals, for immediate intraoperative tissue expansion for closure of small skin defect within one single stress-load cycle is safe and can be easily performed under local anesthesia. Although it is not something that will be used everyday for wound closure but it is a nice technique for a surgeon to keep in mind.

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