

SURGICAL TECHNIQUE

TISSUE EXPANSION: PRINCIPLES, TECHNIQUES & UNWANTED RESULTS

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SUMMARY

The concept of tissue expansion is seen in nature all around us. The ability of our skin to expand and stretch giving extra skin if it is placed under constant, continuous stress over a long period of time has been used for surgical reconstructive goals with the aid of a silicon balloon introduced underneath the skin and progressively injected with saline. This technique needs careful patient selection, a lot of planning and neat execution to successfully do this process, which almost requires 8-12 weeks and involves two surgical sessions. Any compromise in this process can lead to minor and major complications and outcomes. This article seeks to introduce the process, technique and the complications of tissue expansion.

Key words: complications, tissue expansion, unfavorable results

RÉSUMÉ

L'expansion tissulaire: principes, techniques et résultats non désirés

Le concept d'expansion tissulaire est rencontré partout autour de nous dans la nature. La capacité de notre peau de s'étendre et de s'allonger ayant pour résultat une peau supplémentaire si elle est soumise à un stress continu pendant une longue période de temps, a été utilisée à la reconstruction chirurgicale à l'aide d'un ballon de silicone introduit sous la peau et progressivement injecté avec une solution physiologique. Cette technique nécessite une sélection attentive des patients, une planification minutieuse et une exécution adroite afin de réussir ce procédé, qui demande 8-12 semaines et implique deux sessions chirurgicales. Tout compromis peut conduire aux complications mineures et majeures. Cet article essaye de présenter le procédé, la technique et les complications de l'expansion tissulaire.

Mots clefs: complications, expansion tissulaire, résultats défavorables

INTRODUCTION

Human tissue has been documented and observed to have the ability to expand and stretch both in physiological and pathological ways gradually with time.

Examples are many, such as stretching of the abdominal wall throughout pregnancy, Stretching of the chest skin to form a ptotic breast mound following puberty under the effect of hormones. Also pathological situations such as in a Lipoma, Sarcoma, and other malignant tumors.

The first few attempts for tissue expansion were done to the bone, not soft tissue. Codvilla [1] reported elongation of the femoral bone by applying a bony traction in 1905

followed by Magnuson (USA) in 1908 who reported the usage of an external traction device to surgically lengthen shortened bones in the leg. [2] He also reported that this could be used to stretch the soft-tissues of the leg successfully. After that in Italy came Putti in 1921 [3] who showed that continuous traction on bone around a 30 days-duration may result in 8-10 cm of lengthening not only in the bone, but also in the soft-tissue structures such as the muscles, nerves and blood vessels.

Credits for performing the modern ways of tissue expansion go to Dr. Chedomir Radovan at Georgetown University who clinically used it for the 1st time in January 1976 to resurface an arm defect [4], and Dr. Eric Austad who performed his first cases with an osmotically

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driven self-inflating expander manufactured by Dow Corning Medical Products at the University of Michigan in 1977 [5].

Planning for tissue expansion

It is important to make sure that the patient be psychologically stable and has to accept the temporary aesthetic disfigurement due to the expanded balloon. The donor site must be well vascularized, free from any signs of bacterial infection because the presence of any contamination increases to risks of infection and failure of the expander.

About selecting the size, shape and volume: there are many methods used to select the correct size, shape and volume of the tissue expander to be used. This is related to the size of the defect, size and location of the available donor site and expected advancement of a hemispherical domed flap.

Radovan [6] as well as Morgan and Edgerton [7] have said that the tissue expander base must be the same size as the defect to be closed. Gibney [8] recommends that the expander base must be at least 2.5-3 times the defect's width. Van Rappard et al. [9] studied surface area increases of a number of expanders of different size and shape. They recommended that when applying a rectangular or crescentic expander the appropriate size expander would be one in which the surface area of the expander base is 2.5 times as large as the defect to be closed.

In the case of using round expanders, the diameter of the expander base rather than the area of the base must be 2.5 times as large as the defect. An alternative way of choosing an expander is based on the circumference of the balloon portion of the expander. The expander should be of enough volume so that the apical circumference of the dome of skin overlying the fully inflated expander is 2 to 3 times the width of the defect. Manders et al. [10] recommended that using the largest possible expander that will fit into the donor site should be applied.

Whatever be the shape of the expander, circular/rectangular/crescentic, the result will be more or less domed hemispherical flap. Van Rappard et al. [9] suggested that the application of a rectangular expander gives the most effective surface area gained when compared to the round or crescent.

Some surgeons use more than one tissue expander next to the defect, possibly on both sides of it. This allows division of the amount of expansion needed for a certain defect between the two expanders ensures sufficient tissue for coverage if one donor site is inadequate and also decreases the duration of expansion.

Guidelines for insertion of expander

After doing measurements of the defect/lesion and choosing of the right expander size/shape/volume, the incision for insertion of the expander must also be planned regarding the future advancement of the expanded flap and safe dissection of pocket for the balloon. The incision should be next to the lesion where it would be the leading

edge of the advancement flap or it could even be within the lesion taking care that the closure would be safe and secure and that there would be minimal or no expansion of the lesion itself. [10].

The incision can also be away from the defect if the tissue next to the defect needs this safety, for example: a skin grafted area, unstable skin over the lesion etc.

Some surgeons think that the incision must be perpendicular or radial to the expander to decrease the risk of wound dehiscence during the expansion process, but it has the risk of resulting additional scars and disturbing relaxed skin tension lines.

The length of the incision must not be as long as the base diameter of the expander to be used. Usually, an incision of 3-5 cm is adequate for careful, planned dissection of a well, large pocket to easily fit the chosen tissue expander.

The dissection/insertion must be an avascular plane over the muscle fascia. In the scalp and forehead, it may be in the subgaleal plane to minimize the risk of bleeding. The properties of the overlying skin also play an important role in determining this plane. If the overlying skin is scarred and unstable, a deeper plane is chosen to ensure enough skin vascularity and integrity to withstand the stresses of the expansion process. If the skin is kind of thick and more resistant to soft-tissue stretch, the plane could be more superficial. The Dissection process is a mixture of sharp and blunt methods with hemostasis done good along that process.

A separate, kind of tight tunnel and space far from the area of the expander placement is dissected for the application of the injection valve so it can be easily palpable from the surface. This may usually be over a solid base like a bony prominence, for example: the mastoid in the face or over the rib cage/iliac crest in the upper/lower torso. The plane of this dissection must be superficial enough for easy palpation and yet deep enough to avoid pressure necrosis of the skin from the hard valve surface and edges. An absorbable suture of 4-0 Vicryl can be used to retain the tubing in the place where it exits from the tunnel created for the valve so as to ensure that it stays in place, this depends on the personal choice and experience of the surgeon.

Sometimes the valve can be kept externally outside the skin for ease of injection, particularly in the pediatric age-group but the risks of complications are quite high.

When the pocket is dissected, good hemostasis is done. Irrigation of the pocket is done with a solution of povidon iodine or an antibiotic. The pocket is then carefully examined and observed to make sure that there are no gauze threads or any other foreign material within.

The expander is carefully examined for integrity of the envelope, any folds are stretched out gently and the joint of the balloon with the tubing and the tubing with the valve are carefully inspected. A good way to ensure the integrity is to put the expander, tubing and valve in a bowl of normal saline and gently squeeze it to look for any escaping air bubbles. Once it is seen that there is no leakage of the expander, the excess air within the expander is removed by using a No. 24 scalp vein needle inserted into

the valve dome.

Depending upon the relation of the valve placement area (distal or proximal to expander placement site) to balloon, the former is slipped gently into place first or later. This must be a good fit as mentioned above so that it is not displaced due to the patient's movements later. A retaining suture to the adjacent soft-tissue can also be considered. The expander balloon is then gently inserted and smoothened into place in the pocket taking care that the entire base sits comfortably and firmly on the pocket bed without any impingement onto the sides/walls of the pocket and that any folds or sharp edges are smoothened out as much as possible.

The connecting tubing must never lie over the expander, only under it or by its side to avoid any skin erosion.

Closure is then done in 2-3 layers with interrupted buried 3-0 PDS sutures in deep (and superficial layers if necessary) and 4-0 ethilon interrupted or continuous sutures on the skin. Removal of the sutures is done at 10-14 days once good primary healing has occurred.

Once closure is completed, the balloon is further inflated with saline to a capacity enough to (a) close any dead space in the pocket, maintain the pocket size and smoothen out any wrinkles and folds in the expander envelope. The amount of this intraoperative filling of the balloon must be carefully balanced with maintenance of acute tissue vascularity, patient stretch pain and stress on the suture line. Under-filling is preferable to overfilling and risk to tissue vascularity and good stress-free primary healing of the suture line.

The expansion process

A period of 2-3 weeks is needed for good primary healing of the incision suture line with no expansion done. Antibiotics are given and the sutures are removed at 10-14 days.

Patient must be seen weekly for the serial expansion process. After good cleaning of the area (expander placement area plus valve placement area and around) as for any sterile/aseptic procedure, the valve is carefully palpated once again and a No. 24 scalp vein is pierced through the skin perpendicularly into the dome of the injection valve. Using a 10 cc/20 cc luer-lock syringe, gentle aspiration is first done to ensure continuity of the system and smooth return of saline from the expander. Further expansion of the balloon is done with normal saline injected. The amount of expansion needed depends on palpating the expanded dome and seeing if it is still soft and pliable (add some more saline) or tight and tense (end of expansion for that session), also assessing the skin for signs of good capillary return on release of the pressure (tissue tolerance) and patient tolerance to pain. [11] Antibiotics may be indicated if there is any signs of inflammation/potential infection etc.

Removal of expander and flap advancement

When the desired tissue has been obtained, expansion can be stopped. A duration of around 2 weeks is then given

to let the expanded skin to stay stretched to that level.

When the 2nd surgery is performed, one final intraoperative expansion can be done to obtain 1-2 cm of additional tissue. About 20% of the expander capacity can be easily inflated in one final session to obtain a little additional expansion.

At the border between the expander and the lesion/defect, the incision for the advancement flap is usually done. Adequate quantity of saline is withdrawn with the usage of a scalp vein which is inserted into the port to create some tissue laxity over the capsule area. This is done so that the incision in the capsule does not cut into the balloon and burst it. The expander is then carefully removed.

If the flap is kind of short or is a tight fit to cover the lesion, an incision is done with electro cautery to divide the base of the capsule. Also performing parallel incisions may be carefully made in the capsule in the axis of advancement. Excision of the lesion or the defect is done with hemostasis. The flap is then advanced as required.

Sometimes using some absorbable sutures between the capsule (proximal to the advancing edge) and the base/floor of the defect to anchor the flap will decrease the amount of flap retraction and also aid in reduction of any scar stretching by relieving the tension on the actual suture-line.

Use of a suction drain for 24-48 hrs is a matter of choice depending on the surgeon and the case. Surgical closure is usually performed in 2-3 layers, suture removal would be around 8-10 days post-operatively.

Complications and unwanted results

Tissue expansion needs a good patient selection, sterile surgical techniques. Complications may be minor, related to the implant system or major, which needs a change in the surgical plan.

Minor complications include issues related to hematomas' and seromas, valve placement or location, exposure of the valve alone and inadequacy of the expansion related to the defect/lesion. Major complications include cellulitis and closed infections, exposure of the expander balloon itself, deflation of the balloon and ischaemic necrosis of the overlying skin.[12]

Expansion in the lower extremity appears to have the highest rate of complications. This may be related to less vascular supply in the lower limbs. In comparison, expansion in the torso and head/neck shows to have the least complications. [13]

Bleeding into the newly dissected space is an iatrogenic issue. [14] Good hemostasis at the time of expander insertion is very vital. Some surgeons use drains for a period of 24-48 hrs but it has the risk of contamination and infection from the outside. If an hematoma is suspected by the presence of excessive pain, and increased tissue tension, it is advised to open the pocket, and drain the hematoma, irrigate the pocket, and close securely once again with the usage of a 5-7 day antibiotic course. Expansion can be started again after 2-3 weeks once good healing of the incision site is assured.

The expander system is an implant, so it may be

accompanied by significant infections from extraneous sources as well as from contamination within the system. The most common causes are: (1) Peri-operative iatrogenic contamination, (2) infections from folliculitis or abscesses in the skin or adjacent unstable/infected tissue in the lesion/defect and (3) infections related to the injection valve/port.[15]

Another complication is exposure of the tissue expander or/and its valve. The causes are: (1) breakdown of the incision through which the expander was inserted, (2) persistent implant folds causing erosion of the overlying skin and (3) if and when the expander is inserted under unstable thin burnt or scarred skin, under skin grafts or irradiated tissue.[16] Also if the implant pocket is done too small and the implant is placed too close in contact with the suture line.

Also the valve may be exposed from pressure necrosis if it is placed subcutaneously for better palpability and it rests on unyielding underlying bone for the same purpose. the edges of the valve may cause pressure necrosis of the overlying skin. Best method to deal with that problem is to completely exteriorize the valve and look after it with good local antiseptic measures and systemic antibiotics until the rest of the process is completed.[17,18]

Also there is flap necrosis which is due to pressure from the underlying inflating expander. Most commonly, this may be caused by creating too thin a skin flap by dissection in too superficial a plane.

CONCLUSION

Tissue expansion is a vital and important tool in reconstructive surgery but needs a careful and correct patient selection, good planning and precise step-wise execution. It is the best way to deal with lesions and defects resulting from congenital and post-traumatic causes. Like all modalities of reconstruction, also will there always be unfavorable results because of the use of a prosthesis, the long period of the entire process and many intrinsic and extrinsic factors related to the same. However as long as one anticipates these steps and complications and is able to tackle them satisfactorily, it remains one of the most exciting methods in reconstructive surgery in the last 50 years.

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