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Tissue expansion in oral and maxillofacial surgery

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Abstract---Tissue expansion offers s new frontier in head and neck reconstruction by creating an excessive soft tissue, contiguous to the defect, with identical colour, thickness and appendages is a most vital and valuable tool in reconstruction of head and neck which requires meticulous treatment planning, correct patient selection and precise stepwise execution¹⁵. Like other modalities present in oral and maxillofacial surgery have some unfavourable results, tissue expansion is also present with some unfavourable complications. However as long as one anticipates these sequelae and complications and is able to tackle them satisfactorily, it remains one of the most exciting advancements in our field in the last 50 years.

Keywords---tissue expansion, oral, maxillofacial surgery.

Introduction

The observation that living tissues respond in dynamic fashion to mechanical forces placed upon them has been applied to the clinical problem the technique of tissue expansion, based upon the application of this observation, has provided great advantages to the surgeon and patient. The phenomenon of tissue expansion has been occurring in nature constantly both in physiologic as well as pathologic processes. Physiologic processes such as pregnancy, weight loss, weight gain, cranial vault expansion at sutural lining and many more other physiologic processes are observed in nature. In Pathologic situations skin over cyst and tumour expands gradually under the tension and stress. Grabb (1982) translated very eloquently the application of this observation: 'The principle of skin expansion has been staring us in the face¹. The loose skin of the abdominal wall during pregnancy and body skin following massive weight loss have been there for all to see' Other than physiologic and pathologic process there are also presence of some community practices of using tissue expansion to improve their aesthetic by stretching their neck seen especially Burmese women, using bigger rings in their ear seen in tribal women.

Tissue expansion is one of the newest and major advances in oral and maxillofacial surgery particularly for reconstructive purpose². or the reconstructive surgeries tissue expansion provide an alternative to free graft or pedicle flap as it provides tension-free closure at the recipient site and by providing the donor tissue of matching colour, texture and with similar thickness with minor donor site morbidity. Basically, the physiology behind the tissue expansion is that under constant and controlled mechanical overstretching the tissue is created which matches the abutting skin. The goal of the soft tissue expansion is to create the skin adjacent to site which need reconstruction which in turn dwindle the donor site morbidity.

History

Tissue expansion technique was first attempted on hard tissue rather the soft tissue. In 1905, Alessandro Codivilla presented a clinically implemented paper on elongation of femur followed by putty in 1921 proclaim that with gradual traction of bone for certain period not only lengthen the hard tissue but also has potentiality on soft tissue expansion such as muscle, nerve and vessels. Neumann (1957) described expansion of postauricular skin with an air-filled balloon to facilitate ear reconstruction¹⁶. Dr. Chedomir Radovan at Georgetown University who used it clinically for the 1st time in January 1976 to resurface an arm defect and Dr. Eric Austad who did his first cases with an osmotically driven self-inflating expander manufactured by Dow Corning Medical Products at the University of Michigan in 1977 are accredited for contrivance of tissue expansion procedure which we use at present^{4,8}. All the instigators who gave the concepts of tissue expansion have also truthfully conveyed those complications after expansion were high in their early cases.

Biological effects of tissue expansion

Tissue expansion technique exploits the adaptability quality of the tissue and induces a controlled in situ skin growth. Stretches beyond the skin's physiological limit, invoke several Mechano-transduction pathways, which increase mitotic activity and collagen synthesis, ultimately resulting in a net gain in skin surface area³. Austad et al. postulate that tissue expansion causes a decrease in cell density in the basal layer of the skin and that cell density may regulate skin mitotic activity. A lower cell density results in a greater cell proliferation, resulting in growth of additional skin⁴. Inflation of the tissue expander was found to cause a threefold elevation of epidermal mitotic activity within 24 h, followed by a gradual return to normal baseline over 2–5 days. Conversely, deflation of the expander caused a transient decrease in epidermal mitotic activity⁵. The increase in mitosis returns to normal 4 weeks after expansion. On histologic studies, the epidermis has an increase in its thickness and the rete pegs become flattened when compared to nonexpanded skin. A capsule form around the expander as with most foreign body reactions. These capsules are thickest after 2–2.5 months of expansion. Within 7 days there is a 2-layer capsule consisting of an inner layer of macrophages and an outer layer of fibroblasts and some lymphocytes. Over time the outer layer becomes richer in collagen fibers. The bordering layer around the capsule becomes richly vascularized². Once an expander is removed, the surrounding fibrous capsule rapidly thins. Following the removal of the tissue expanders, the dermal layers change to normal condition within 1.5 to 2 years. Four zones within the capsule have been described by Paysk. The inner zone is composed of fibrin and macrophages, the central zone contains fibroblasts and myofibroblasts, the transitional zone is composed of loose collagen, and the outer zone contains blood vessels and collagen.

Indications

Tissue expansion has many diverse clinical applications. It may be used in the correction of congenital or acquired deformities⁶. These include scar or defect revision following trauma as well as deformities like cleft lip, cleft palate. It can be applied to various regions of the body including the head and neck, extremities, trunk and groin. Some of the more common indications of tissue expansion are soft tissue expansion before alveolar ridge augmentation, forehead nasal, cheek and neck and eyelid reconstruction, scar revision, expansion of postauricular skin prior to reconstruction of the external ear, treatment of posttraumatic alopecia, male pattern baldness, breast implants, burn excision, and for other regional reconstruction where primary closure is needed⁷.

Contraindications

Contraindication of tissue expansion include; active infection anywhere in the body, clinically persistent or recurrent cancer, poor vascularization of tissue in the area where the implant is to be used, history of compromised wound healing, compromised immune system, history of sensitivity to foreign materials, insufficient tissue covering and unwillingness or medical inability to undergo 2 or more operations or to comply with the numerous outpatient visits required for the expansion process, noncompliance, mental disability. It is important that the

patient be psychologically stable because he/she has to accept the temporary aesthetic disfigurement due to the expanded balloon¹.

Expanders

Expanders are produced in a variety of sizes and shapes. They can be classified as standard (round, rectangular or crescentic), differential (allowing more expansion in one site than another due to a differential stiffness of different parts of the expander), anatomic expanders for breast reconstruction or custom-made expanders for a particular defect^{1,6}. Most expanders consist mainly of a silicone balloon with an injection port and are usually made in commonly required capacities from 50 cc to 1000 cc in increments of 50 cc-100 cc. Radovan was the one who invented a silicone expander with sealed remote injection port. The expander and remote injection dome are for temporary subcutaneous or submuscular implantation and is not intended for use beyond six months⁸. The expanders are inflated over a several days depending on the tissue needed for reconstruction. Therefore, patient has to visit for several days which is inconvenient to patient as well as to surgeon that's why home inflation of tissue expansion has been developed which did not gain much popularity owing to various complication arises by it. The inflatable expander can be damaged by needle which is generally use to fill the expander through filling port that why filling port can be connected to the tube so the expander and filling port are at distant where possibility of deterioration of expander is not possible.

The latest generation of expanders made up of hydrogels. Unlike the balloon expander, hydrogel expanders are self-inflating and therefore have no filling port. Hydrogels are cross-linked polymers that have hydrophilic groups and can therefore absorb fluids. The material properties range from hard and tough to soft and weak, depending on the number of inhibited fluids⁹. The Osmed hydrogel tissue expander is based on an osmotically active hydrogel. The self-filling device is made of a cross-linked hydrogel consisting of co-polymers based on methyl-methacrylate (MMA) and N-vinylpyrrolidone.

Selection of expander

Selection of expander depends on size, shape of the defect, area to be reconstructed, availability of tissue adjacent to area to be reconstructed^{1,7}. Gibney suggested that the expander base must be at least 2.5-3 times the defect's width¹⁰. Radovan as well as Morgan and Edgerton have suggested that the expander base must be the same size as the defect to be closed¹¹. So, a doubling of the dome surface would theoretically allow coverage of both defect and donor site. van Rappard et al. studied surface area increases of a number of expanders of different size and shape¹². They recommended that when using 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 round expanders, the diameter of the expander base rather than the area of the base should be 2.5 times as large as the defect¹.

The base dimensions are a more useful guide than volume in choosing an expander as most expanders can be over-inflated to many times their nominal

volume before implant failure occurs. Joss et al. determined that, regardless of its shape, an expander twice as wide as the defect to be covered would produce enough tissue to cover both the donor site and the defect. For an additional margin of safety, it is recommended that expanders be two-and-a-half to three times the size of the defect to be reconstructed.

Manders et al. recommended that the largest possible expander that will fit at the donor site should be used. That way, even if the chosen expander creates excessive skin, suturing the expanded flap of tissue without tension will keep widening of the post-operative scar to a minimum. This logic has its roots in the phenomenon of 'tissue stretch-back' which is the ability of expanded tissue/tissue stretched over a long period to contract back immediately after the tension is relieved or to shorten slowly over time. This can result in a wide stretched scar, secondary distortion of an adjacent mobile structure or hypertrophicity of the scar¹³.

van Rappard et al. estimated that use of a rectangular expander provides the most effective surface area gained when compared to the round or crescent. Rectangular expanders gain 38% in tissue area of the calculated surface increase of the expander, whereas round expanders gain 25% and crescent expanders gain 32% of calculated surface increase. Hence always use rectangular expander when there is need to harvest more tissue for reconstruction¹².

Insertion of expander

Preoperative treatment planning is imperative to for insertion of tissue expander into the required areas. After meticulous planning, selection of implant size, shape and volume, demarcating the dimension of the expander on surgical site is the best course of action for surgeon to make¹⁴. One should make the incision on the normal healthy tissue. In case of burn patient, the incision should be adjunct to the tissue which is burnt rather than on the burn tissue. The design of incision is also depending on the planned direction of future advancement of expanded flap. Hence the incision could be lie adjacent to the tissue to be expanded where it would be a leading edge of advancement flap or it could be in lesion but it should not lead to expansion of the itself. Incision can be 3-5 cm in length is adequate for dissection of pocket to insert the expander.

An avascular plane or a plane which minimizes bleeding during pocket dissection is infinitely preferable. The tissue expander is placed subcutaneously, in case of scalp and forehead it should be sublegal plane. The plane of this dissection should be such that it is superficial enough for easy palpation and yet deep enough to avoid pressure necrosis of the skin from the hard valve surface and edges. If the overlying skin is scarred and unstable, a deeper plane is chosen to ensure sufficient skin vascularity and integrity to withstand the stresses of the expansion. If the skin is thick and relatively more resistant to soft-tissue stretch, the plane could be more superficial¹. The pocket which is dissected for the tissue expander should be greater in diameter than the expander itself, or the expander will erode through the wall of cavity by pressure necrosis. The expander should also be emptied before insertion into the pocket. Once it is placed in to the pocket the expander should not be visible. These measures are designed to rule out the

possibility of expansion of scar tissue which is adjacent to expander, whose expansion will waste the expanded tissue and limits the size of the flap for reconstruction.

The filling port is inserted in the separated subcutaneous tissue through the same incision. This should be snugged fit so that it is not displaced due to patients movements. To achieve this resorbable suture to the adjacent soft tissue can be consider. The location of injection port should allow easy percutaneous access which is ideally should be 7cm away from the expander. it is recommended that the injection port should be placed on solid platform such as bone as it makes it easily accessible and easy to palpate.

Absolute hemostasis is essential for the success of expansion. Though the use of expander is ambivalent, it should used to drain the hematoma or seroma that may collect and to decreases the dead space. The suction tip should be inserted in an expansion pocket prior to the placement of expander. Expander should be filled with only that much of saline which will allow the sufficient wound closure. The intraoperative expansion of the implant is very important as it results in filling of the dead space, hematoma reduction, seroma prevention and finally smooth outs the folded and wrinkled margins of expander. Inject 10% of volume of expander at the time of insertion. The flap is created after the tissue expander is inserted in expanded pocket. It has shown that 10% of volume of expander does not compromise the vascularity. The incision is closed in layers taking care not to puncture the expander. Strict asepsis and meticulous hemostasis are critical factor of the implantation procedures.

Inflation of the expander

2-3 weeks after the expander is inserted in to expansion pocket the expansion procedures commence weekly or twice weekly to produce a sufficient soft tissue for reconstruction. Healing of wound which was made for the insertion of expander should be closely monitored because the expander can erode through the incompletely healed incision site. The body tissue reaction has already formed the thin sterile capsule around the expander in this time. Prophylactic antibiotics are given to the patient for the first few days which should be effective against skin flora.

Patient should be called regularly for inflation of expander. The inflation of the expander can be done without administration of local anaesthesia in outpatient basis. Initially the expander should be filed slowly, increasing the as the process continues. The amount of inflation is decided by a) palpating the expanding dome and assessing if it is still soft and pliable which will allow more saline or tight and tense which will lead to an end of that expansion session b) assessing the skin for continued blanching on pressure at multiple point and good capillary return on release of pressure c) patient tolerance for pain and discomfort with feeling of too much tightness will stipulate the end of inflation for the session. Inflation should be terminated when pain is beyond the limit of tolerance of patient. topical aesthesia can be used in case of children.

The systemic entry of additional expansion done and volume achieved in every visit should be noted down in the expansion chart. Any problem which is encountered during each procedure should be inscribed for study and medicolegal purpose. An antibiotic should be prescribed if there is evidence of any infection or inflammation. Analgesics are given to patient in case if there is pain after inflation of expander. Patient should be well educated about the procedure and should be ready to accept the physical disharmony. The expansion continues till the approbated expansion has been achieved.

Removal of expander

After completion of preplanned expansion usually 2 weeks given to the expanded tissue to remain stretched. During second surgery on final expansion can be done to obtain additional 1-2 cm of tissue. The incision to the advancement flap is usually at the border between expander and the lesion. This incision is deepened till the capsule and adequate amount of saline is removed to create the tissue laxity and decrease the chances of puncture of expander. The expander is then gently removed and the tunnel that will lead to port will be dissected out the port should be removed⁸.

A trial advancement of the expanded flap across the lesion/defect is then made to assess the reach of the flap and if the flap appears to fall marginally short or is a tight fit, an incision is carefully made with electrocautery to divide the base of the capsule. If any more release is necessary, then parallel incisions may be carefully made in the capsule in the axis of advancement. It is very rare to need a complete capsulectomy to unfurl the flap fully. Once it is confirmed that the expander will cover the entire defect/lesion, excision of the lesion or final preparation of the defect is carried out and haemostasis confirmed. The flap is then advanced as required. Closure is usually done in 2-3 layers, deep suturing with absorbable sutures (3-0 Vicryl, PDS, Monocryl) and skin closure with either subcuticular PDS or Monocryl or a running stitch of 4-0/5-0 ethilon. Suture removal would be at 8-10 days post-operative.

Complications related to tissue expansion

Vigilant patient selection and meticulous treatment planning and dedication toward the patients is mandatory to avoid the complications which may arise during or after the procedures. Complications which arise with the tissue expansion procedure can be major or minor, which can be related to the implant itself (size, shape, volume) or on the patient, or due to failure to achieve the goals by poor surgical management. Minor complications include issues related to haematomas and seromas, valve placement or location, exposure of the valve alone and inadequacy of the expansion related to the defect/lesion. Major complications include (1) cellulitis and closed infections, (2) exposure of the expander balloon itself, (3) deflation of the balloon and (4) ischaemic necrosis of the overlying skin¹.

Hematomas are nothing but the bleeding into the newly dissected space, which is iatrogenic cause due to inadequate haemostasis at the time of expander insertion. It is a minor complication which is usually resolved by reexploring the surgical site,

meticulous haemostasis and insertion of expander again. A seroma is a build-up of clear fluid inside the body. It happens most often after surgery. A seroma is not often dangerous, but it can cause pain and discomfort. Aspiration and drainage can resolve the seroma.

Infection is another complication which can be so bizarre that one might have to stop the expansion process. It might arise due to inadequate sepsis, contamination of expander (bacteria etc), or presence of infection of skin. Broad spectrum antibiotics should be started and if the infection is at its utmost, re-exposure of site, copious saline irrigation or temporarily remove the expander is the possible option. Culture sensitivity must be done to start appropriate antibiotic treatment.

Cellulitis of the overlying skin seen later in the process is usually due to contamination with abscesses under scabs or due to some lapse in strict asepsis during the weekly inflation process. It may be due to poor blood supply to the area which pre-disposes to infection. Cellulitis is the emergency condition and should be treated on an emergent basis by: (a) Stopping expansion temporarily, (b) deflating the expander by 10% to minimise any ischaemic compromise, (c) instituting immediate antibiotic and anti-inflammatory cover and (4) local treatment with fomentation with glycerine/magnesium sulphate. this treatment will allow resumption of the process within 7-10 days. If in spite of this treatment, if the infection progresses systemic signs and symptoms, then a decision about removal of the expander is imperative.

The capsule may be thickened in the middle of expansion process which offers great resistance to expansion which is the result of subclinical infection. Patient is in unusual pain as there is resistance to expansion due to thickened capsule. There is a backflow through the valve licking through skin. A decision may need to be taken to cut losses, abandon the expansion process and remove the expander. Whether a capsulotomy or capsulectomy is necessary at that point is a matter of surgeon discretion. Without the expander within, capsules are known to disappear within 6-month time. The surgeon can then consider re-insertion of the expander after a minimum of 3-6 months.

The cause for extrusion of the expander through the incision is usually due to from too small implant pocket results in the implant is placed too close in contact with the sutureline. If breakdown of the incision occurs early in the process is detected immediately, there exists a chance to try and salvage the process by widening the breakdown area, checking for any implant folds and correcting them, cleaning out the pocket with thorough lavage, replacing the expander and resuturing in layers, followed by coverage with appropriate antibiotics. The expansion process is then delayed until such time as the new closure heals fully, usually 2-3 weeks. If implant exposure occurs later in the process, it is usually due to instability of the overlying skin or abnormal thinning of the skin leading to skin breakdown either due to mechanical pressure from the expander (folds or otherwise) or an ischaemic process. If however the exposure is large and the goal of expansion is far away, then attempts at salvage are mostly futile and it is time to cut losses and abandon the process. The process may be re-attempted 6 months later after strong healing of the dehisced area.

The deflation of the balloon is the major complication and the usual causes of implant deflation and failure are: (1) severe trauma to the area due to poor care of the expander or deliberate injury, (2) massive overexpansion well beyond the capacity of the expander to stretch resulting to bursting and (3) poor quality of the expander itself (4) due to misdirected needle pricks into the expander envelope itself. Unfortunately the management of deflated balloon is replacement of the entire system.

Flap ischaemia and skin necrosis is the dreaded complication as it directly affects the skin which is designed to be recruited from expansion process. Most commonly, this may be caused by (1) creating too thin a skin flap by dissection in too superficial a plane (2) poor quality skin such as after irradiation or when the expander is placed under skin grafts or atrophic skin (3) by too rapid or too much expansion in a short period (4) Persistent implant folds also predispose to skin necrosis in that area. If impending skin loss is noticed early by the signs of persistent pallor of the flap and poor capillary return on pressure release, then the expander must be immediately deflated to allow for maximum tissue perfusion and the skin flap observed. If the skin is already necrosed and irreversibly damaged when noticed, then early debridement of the necrotic skin is mandatory to avoid infection. In such cases, the process of expansion is abandoned, the expander removed and the wound closed and allowed to heal.

Bone resorption, neuropraxias and nerve dysfunctions are another rare complication of tissue expansion. Large series have demonstrated that the complication rate has been shown to decrease with increasing experience of the procedure, showing that a significant learning curve exists for this procedure.

Conclusion

Tissue expansion offers a new frontier in head and neck reconstruction by creating an excessive soft tissue, contiguous to the defect, with identical colour, thickness and appendages is a most vital and valuable tool in reconstruction of head and neck which requires meticulous treatment planning, correct patient selection and precise stepwise execution¹⁵. Like other modalities present in oral and maxillofacial surgery have some unfavourable results, tissue expansion is also present with some unfavourable complications. However as long as one anticipates these sequelae and complications and is able to tackle them satisfactorily, it remains one of the most exciting advancements in our field in the last 50 years.

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