The volume of fluid injected into the tissue expander and the tissue expansion

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Background: Replacement of the lost tissue is the major concerns of the plastic surgeons. Expanded area should be coherent with the surrounding tissue. Tissue expansion technique is the reforming methods the skin tissue scarcities. Several methods for tissue expansion are available; including usage of silicon balloon and injecting fluid into the tissue expander. **Materials and Methods:** In a clinical trial study, 35 patients, with burn scars, in the face, skull and neck area were studied. We provided a tissue expander device with capacities of 125, 250 and 350cc. Fluid was injected inside the device, 3 consecutive weeks with 1-week interval. After 3 months the device was set out and the tissue expansion was measured using a transparent board and the results were analyzed. Multiple regression was done by SPSS 20 to analyze the data. **Results:** Regression model showed Skin expansion was positively correlated with the volume of the injected fluid. For each centimeter square of skin expansion, about 6-8 ml of fluid must be injected. **Conclusion:** Correction of skin defects resulting from burning scar is possible using tissue expanders. The tissue expansion is correlated with the amount of the injected fluid.

Key words: Tissue expansion, flap, scar excision

INTRODUCTION

Skin defects might be decreased self-esteem, the quality of life and the social role of injured person, it also can be visually unpleasant. The scar caused by burning involve cosmetic and deformity, even after skin grafting.[1] "Tissue expansion is one of the extreme revolutions of the 20th century in plastic surgery".[2]

Tissue expansion to rebuild the skin defects was presented as a repair method by Neumann.[3]

Skin and soft tissue have the ability to create tissue in reaction to tension.[4] Tension is produced by inserting a subcutaneous expander that is filled with fluid over weeks; persistent extending of the skin produces new tissue that can be used to restructure defects such as those come across after burn. This new skin allows to close the supporter site to end of the damaged area.[5]

As an overall instruction, the length of the extended flap should be two to three times the diameter of the skin that is to be excised. Deformity and multiple surgery are the common disadvantage of this method. The advantage of the tissue expansion is preserving it's color, texture, hair-bearing qualities and innervations; therefore, this technique is suited the best for the head-neck region and breast.[6,7]

Taking an expander for a specific defect remains a major concern for plastic surgeons. There are many mathematical, geometric and computer-based models to calculate the needed expansion for choosing the correct expander size.[6]

In this study we estimated, the volume of fluid needed for each centimeter square of skin expansion.

MATERIALS AND METHODS

Thirty-five patients with a burn sequel were included in the study since 2005 and 2009 at a burn center affiliated to Isfahan Medical Science University. The physical examination was carried out during the first consultation.

Inclusion criteria

Normal skin on the borders of the scar should be as large as possible. All patients had unacceptable scares, caused by burns, surgical and large mole scars. The scar tissues were located in the head and neck area and at least 2 years had passed since the early injury. Since the elasticity of the skin decreases in by age, we included

under 35-year-old patients in the study. Patients with a history of radiation on scar were excluded from the study.

Intervention

After filling an informed consent form, the skin defect was marked and measured with transparent checkered plates. By this method, location of the device was determined. We used an injection valve port connected to the device by silicone tubes of customized length. The valve was located at a distance in a subcutaneous level, over a firm Supportive tissue to prevent downturn or migration. The previously planned pocket was inserted in a subcutaneous level. Then the tissue dilator was placed in the pocket under the skin [Figure 1].

We used, 125, 250 and 350cc devices with round and cylinder shape, depending on the size and location of the scar.

Serial expansions were performed, 3 weeks postinsertion. 1/13 volume of the devices was injected weekly.

After 3 months the device was removed and the skin flap was measured by transparent checker plate.

Reconstruction

Under general anesthesia, we designed a flap with the expanded skin, then after making a cut we inserted the flap in the skin defect.

The valve was removed through an incision [Figure 2].

We tried to increase the expanded tissue by good perfusion. We did several capsulotomies in the same places to promote the advancement of the flap with minimum incision. The flap was redesigned and the defects substituted with the available tissue. The incision was sutured using two neddles of vicryl 3-0 and nylon 5-0 (in the scalp we use one plane of nylon 3-0) over a suction drainage that was removed after 24 h.

Blinding and random allocation were not possible because of the design. We used descriptive statistics for describing sample's characteristics as a total number, Percentage, mean and standard deviation. For prediction of model, multiple regressions were done. The main outcome was considered as expanded tissues (cm^2) by each unit of fluid. The potential predictors were sex, age, and the injected fluid volume. Other variables such as scar size and location of scar, which not contributed in model, were removed from the model. Analyzes was done by SPSS version 20 (SPSS Inc., Chicago, IL, USA).

RESULTS

In this study, 35 patients were eligible for intervention. All patients were followed for 3 months according to the protocol, and no loss was observed. The outcome of study was amount of skin flap, size of skin expansion. Table 1 shows the demographic characteristics of the patients.

In multiple regression, sex, age and volume of the injected fluid were as predictors of the tissue expansion.

Pearson correlation between the injected fluid and tissue expansion was $r = 0.98$ ($P < 0.001$). The coefficient of determination was $R^2 = 0.98$. It shows that 98% of the variation of the tissue expansion is explained by the injected fluid. Table 2 shows the mean and standard deviation of the injected fluid and tissue expansion according to gender.

The difference was not find in quantity of the expansion with regards to gender (Pv > 0.05).

Table 3, shows the relationship between the injected fluid and the volume of tissue expansion according to the age groups. As shown in the Table 3 the patients with age 20-24 need more fluid to expand and their response to the injection is higher than other age groups.

Figure 1: Pre

Figure 2: Post

Table 1: The characteristics of study subjects

Characteristics	Number	Percentage
Sex		
Male	13	36
Female	22	64
Age		
≤19	12	33
20-24	13	36.1
25-35	10	30.6

Table 2: Comparison of the mean and SD of injected fluid and tissue expansion according to gender

	Gender	
	Male	Female
Injected fluid (cc)	179.5±78	174±93
Expansion (cm^2)	25.5±11.3	25±15.7

SD = Standard deviation

Table 3: Comparison of the mean and SD of injected fluid and tissue expansion according to age groups

	Age groups		
	<19	20-24	≥25
Fluid (cc)	165±80.12	201±96.4	163.3±67.5
Expansion (cm^2)	23.5±12.7	28.85±15	23±10.13

SD = Standard deviation

The estimated equation was: $Y = 17.9 + 6.3\ (X)$. Where the Y was amount of tissue expansion and X was the injected fluid. No side effects are observed through follow-up.

DISCUSSION

Skin expansion is a routine technique for reconstruction of many congenital and acquired defects in children and adults.[8] Surgeons occasionally face inadequate tissue for reforming, that is the main problem of this advanced surgical technique. Although the Tissue expansion causes widening of the tissue, many factors that increases required tissue are needed.[5] The surgeon has to organize these extra requirements. So far the major reason of surgical results failure was attributable to the kind of the expander and the amount of fluid injection.[9] Different ways of estimation can be used, like mathematical calculations and computer programs.[10,11]

But they are not popular and applicable. Because choosing the expander should be determined by shape, size and part of the body that is injured. As well as Injecting low amount of fluid may lead to tissue shortage, injecting large amounts of liquid may cause a skin condition named as do gear, that a new excision should be done to reform it.[12]

The aim of our study was formulating an equation to estimate the required amount of expansion for each patient. After that the amount of the liquid, which was adequate to reach the proposed stretching was calculated. Our findings met the amount of the liquid needed to make a square centimeter of tissue expansion. In this study, for the dilator with the capacity equal to 350cc, 7-8cc of fluid was required to achieve a square centimeter. But in the dilators with the capacity equal to 350cc 125-250cc, 6cc of fluid was sufficient This finding was consistent with the study of Raposio and Nordström.[13] He has proposed a formula, in that the fluid volume required is equal to: Width multiplied by the area of the skin defects, multiplied by 1.5.[13]

Since the most of the defects do not have a geometric shape, it is difficult, to calculate fluid requirements.

In our method, estimation of the skin surface with transparent checkered plates was identical straightforward. Considering the obtained equation, we will be able to plan the fluid requirement and approximate length of treatment.

We included patients with ages younger than 35 years, with scars in head and neck, therefore externalization of our finding in the older patients and scars in other parts of the body should be done with caution.

CONCLUSION

With careful selection of patients, good planning and performance of the procedure, postoperative follow-up and cooperation with patients, tissue expansion is a useful method for reconstruction of the skin defects.

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AUTHOR'S CONTRIBUTION

All authors have contributed in designing and conducting the study. All authors have assisted in preparation of the first draft of the manuscript or revising it critically for important intellectual content. All authors have read and approved the content of the manuscript and confirmed the accuracy or integrity of any part of the work.

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