Original Article - Evaluative Study

A single center experience of craniofacial tissue expansion and reconstruction

Access this article online
Website: www.amsjournal.com
DOI: 10.4103/2231-0746.161057
Quick Response Code:

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ABSTRACT

Introduction: Tissue expansion is a versatile technique for craniofacial soft tissue defects. It has been extremely useful to restore the form and function along with good esthetics that were otherwise unobtainable. **Objectives:** To review the use of tissue expansion in the craniofacial region, with particular emphasis on indication, site, days, volume of the defect and tissue expansion used along with complications. **Materials and Methods:** Retrospective review of data on 18 expanded flap reconstructions performed in 14 patients during the period 2008–2013. Tissue expanders were placed on a subcutaneous plane above the fascia and inflated weekly. The expanded skin was used as a transposition flap for the reconstruction. Data were collected from archival records and tabulated in SPSS. Descriptive statistics, Kruskal–Wallis and Mann–Whitney tests were applied as required and a $P \leq 0.05$ was taken as significant. **Results:** Trauma contributed to greater number of defects (57.1%). The most common defect occurs in face/cheek compartment (57.15%) followed by nose (35.71%). Owing to ease of access and better results, more expanders have been placed in cheek (50%), followed by neck (33.33%). The mean defect size was 2983.58 ± 828.27 mm^2, required 32.14 ± 6.31 days, 335.6 ± 156.51 ml in 5.29 ± 1.5 cycles of tissue expansion. The mean rate of expansion was 59.17 ± 16.27, 69.11 ± 30.19 and 62.6 ± 25.75 for forehead, face/cheek and neck cases respectively ($P = 0.873$). **Discussion:** Laxity of skin appears to be a good indicator of the rate of the expansion. The most favorable site for tissue expansion is cheek followed by neck. The study also shows that tissue expansion is an efficient and valuable technique for reconstruction of large craniofacial skin defects.

Keywords: Craniofacial soft tissue defect, reconstruction of skin defects, tissue expander

INTRODUCTION

Deficiency of craniofacial skin could be due to various causes including trauma, burns, tumor resection and rarely due to congenital defects. The replacement of craniofacial skin in such instances are a daunting challenge. The solution includes loco-regional or distant flaps, pedicled or free transfer flaps, artificial substitutes and if available donor grafts.[1] The alternate concepts include tissue expansion and distraction histogenesis (if performed along with bone distraction). The concept of tissue expansion was postulated by Neumann in 1956. He presented a case of successful ear reconstruction for missing auricle, using a prototype of implanted balloon in the temporal region. Though that case was quite successful, it was not immediately integrated into practice. It was in mid-1980's that tissue expanders were

Cite this article as: Balaji SM. A single center experience of craniofacial tissue expansion and reconstruction. Ann Maxillofac Surg 2015;5:37-43.

again brought into attention by the efforts of Radovan and Avustad as reported by Bauer.[2]

The tissue expansion uses artificial, prefabricated/customized implants in the tissue planes below the skin and is inflated slowly. The inflation of the implant exerts a constant pressure on skin causing it to expand. The principle of the tissue expanders is based on the mechanical and biological creep. Mechanical creep refers to morphologic changes that occur in cellular level in response to the applied stress (inflation of the implant) and the resultant expansion of skin surface is the biological creep. For an optimum growth, the mechanical and biological creep needs to be identical.[2] With inflated implants, the resultant stress induces growth of the tissue restoring resting tension of the stretched tissue to baseline, so that the responsive growth ceases. At this juncture, the implant is inflated again. The process is continued till the desired dimension of the tissue is achieved. The epidermis gets thicker with concurrent thinning of the dermis and alignment of collagen fibrils occurs once the complete remodeling occurs.[2]

There are only few reports of tissue expanders in the head and neck region.[1,3-5] The goal of this manuscript is to present a single center's experience over a period of 6 years in craniofacial tissue expansion for the extended flap.

MATERIALS AND METHODS

This is a study of 6 years (2008–2013) from the author's institution. All cases of craniofacial tissue expansion with a minimum of 6 months follow-up were collected from archives. Only cases that had adequate details were included in the study. The details of age, gender and cause of defect were noted. The defect size was measured using the following method. A sterile, thin silver foil was atraumatically pressed over the skin defect, creating a mold. After carefully removing the same, the edges were trimmed. This foil was then kept over a standard graph paper (graded by 1 mm × 1 mm) and the number of squares involved (>50%) was counted. This was repeated thrice and average taken as the mean defect size. The number of days required for completing the desired level of expansion, number of increments and the total volume of saline used was collected from the records.

For this study, the complications were classified as major and minor categories. Any complications that delayed the process of expansion and reconstruction were considered as major categories. Potentially, it includes hematoma, infection, expander exposure, flap ischemia, perforation due to percutaneous stabbing. Other complications such as bleeding, pain and temporary paresthesia were considered as minor complications, as they did not affect the treatment plan.

Procedure

The procedure was carried out in three distinct stages. In the first stage, the expanders were placed in position and secured. In the next phase, the expanders were inflated in a controlled phase. In the final phase, the removal of the expander and the reconstruction of the defect were done.

Tissue expanders

In all cases, either crescent or rectangular expanders with a hard base bottom and a remote injection port (Silimed, Brazil) were used. Expanders were typically overinflated beyond the manufacturer's recommended full capacity.

Operative technique

Expander insertion

All of the expanders are placed in patients under standard general anesthesia. All patients received one dose of intravenous antibiotic coverage an hour before the procedure. Adequate care for incisonal design was given. The postoperative flap design dictates the placement. In places of head, incision was placed along natural creases such as nasolabial folds or along folds of neck.

Incisions for placement of the expanders were carefully planned, with the most important consideration being the design of the final flap. The expander pocket was at least 1–2 cm larger than the expander in each dimension. This was to ensure that the tissue expander will lie comfortably in the tissues without being damaged and being protected when expansion occurs. Diligent care was taken during the first and third phases so as to minimize trauma to the skin flap being elevated. In all the considered cases, only internal remote injection ports based tissue expanders were used. Only a low profile port was used and placed in areas where there is no potential pressure on the overlying skin. The distance from port to expander was marked so that no inadvertent puncture can occur.

After insertion of the expander, the pocket is closed with two layers of sutures. The inner was a resorbable suture that was placed tensely. The outer most skin one was a nylon suture. This was not tightly placed and is not removed throughout the entire process of expansion. We routinely use drains, with one drain placed in each expander pocket. Standard antibiotic and pain killers were prescribed as required. The drains are removed on 5th postoperative day.

Expander inflation

The inflation process is initiated 1-week after expander insertion. The injections are repeated once every 5–7 days weekly basis. The volume of expansion varies according to the size of the expander and the anatomic site in which it was implanted. On an average, the volume ranged from 30 ml to 50 ml. Inspection of skin color, capillary refill and simple palpation are performed pre and postinjections. Patient's comfort was also confirmed.

Flap reconstruction

After the expansion has been completed, the patient is ready for the reconstructive surgery [Figures 1-10]. Local and regional expanded flaps are the cornerstones of the reconstruction in most cases; expanded full-thickness skin grafts, expanded free flaps, and expanded prefabricated flaps are used far less frequently.

Statistics

All data were collated and entered in SPSS package, version 16.0 (IBM, IL, USA). Parameters such as volume/cycle, size of defect/days required, size of the defect/cycles were derived. Descriptive statistics

Figure 1: Case 1 – (a) Frontal and (b) lateral view of a patient with a burn injury on the left side face and neck

Figure 3: (a and b) Saline injected periodically to expand the tissue expander and in turn expand the overlying skin

Figure 5: (a) Scar tissue removed, (b and c) defect reconstructed with expanded flap

for the predictors, outcome and derived measures are presented. Nonparametric tests such as Kruskal–Wallis test and Mann–Whitney U-test were applied as appropriate to find the association of the site of defect and site of expansion based on patient characteristics. $P \leq 0.05$ was considered as statistically significant.

RESULTS

In all, 18 patients underwent craniofacial tissue expansion in the center during the study period. Of these 18 cases, 14 patients fulfilled the inclusion and exclusion criteria, and thus included for this study. The mean age was 24.43 ± 4.86 years. Four of the patients required 2 expanders, making a total use of 18 expanders. In all cases, we had no major complications. There were two instances of minor complication-one a late hematoma during inflation and the second one an episode of infection. Both episodes were successfully managed with adequate local treatment. The characteristics of the study group are given in Table 1. Size of the defect was significantly different among gender ($P = 0.053$) but

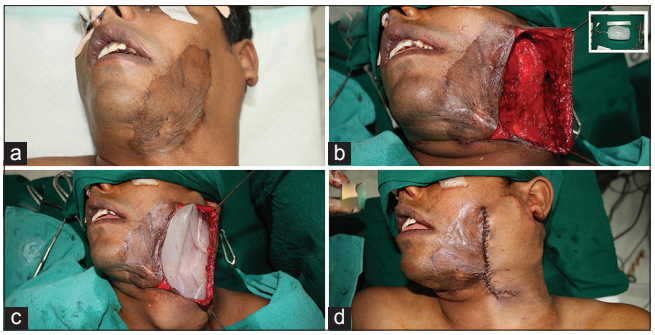


Figure 2: (a) Scar tissue of burn injury, (b) pocket created (expander device seen in inset), (c) tissue expander placed (d) pocket closed in layers

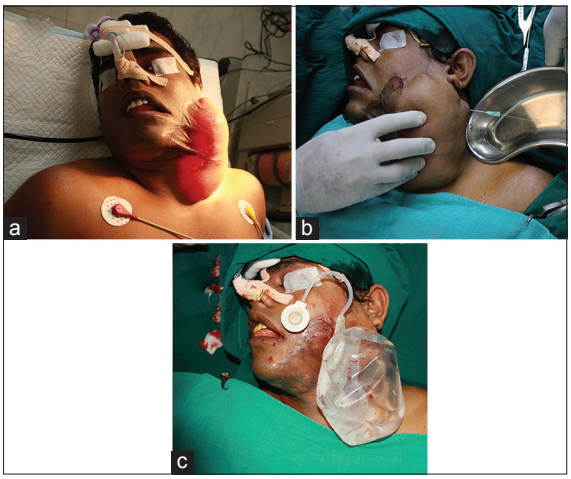


Figure 4: (a) After required amount of tissue is expanded, (b) saline drained, (c) expander device deflated and removed

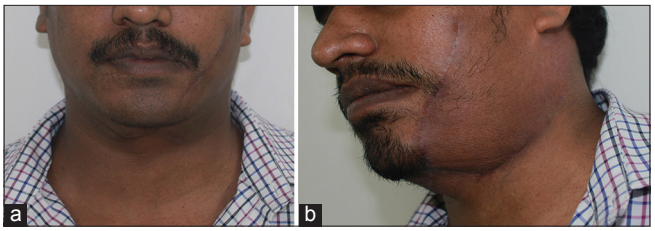


Figure 6: (a and b) Postoperative appearance few months after tissue expansion and reconstruction. Good color match achieved with hair-bearing flap

not related to number of days required for expansion ($P = 1$) or total volume of tissue expansion fluid ($P = 0.456$) or total number of cycles ($P = 0.165$). Table 2 shows the influence of the cause for the defect and its influence on the tissue expansion. The size of defect was significantly (borderline, $P = 0.059$) related to the cause of the defect. The number of days and total volume of fluid required for expansion were related with statistical significance ($P = 0.044$ and $P = 0.003$, respectively).

On studying the tissue expansion characteristics based on site of defect, borderline significance was observed in between defects of nose, face and cheek and neck ($P = 0.057$) while that was significant ($P = 0.011$) for the total number of days required to complete the tissue expansion. The volume of tissue

Figure 7: Case 2 – (a-c) Burn injury in a young girl - frontal and lateral profile

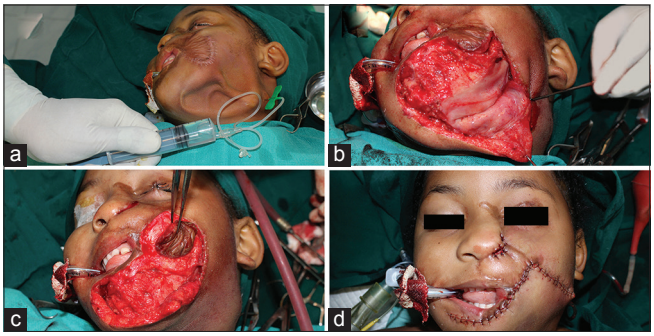


Figure 9: (a) Expander drained, deflated and removed, (b-d) defect reconstructed using expanded flap

Table 1: The demographics and expander characteristics of the study population (*n*=14)

	n (%)
Gender	
Male	5 (35.7)
Female	9 (64.3)
Cause of the defect	
Burn	6 (42.9)
Trauma	8 (57.1)
Site of defect	
Nose	5 (35.71)
Face and cheek	8 (57.15)
Neck	1 (7.14)
Number of expanders	
One	10 (71.43)
Two	4 (28.57)
Site of expander placement	
Forehead	3 (16.7)
Face/cheek	9 (50)
Neck	6 (33.3)
Shape of expanders	
Rectangular	15 (83.33)
Crescent	3 (16.66)
Mean defect size (in mm^2)	2983.58±828.27
Mean days to complete expansion (in days)	32.14±6.31
Total volume of expander (in ml)	335.6±156.51
Total number of cycles	5.29±1.5

Figure 8: (a) Tissue expander device of appropriate size selected according to extent of defect, (b) pocket created, expander device placed, (c and d) skin expanded by periodic inflation of the device

Figure 10: Improved postoperative appearance few years following tissue expansion and facial reconstruction

expansion fluid was directly proportional to the size of the defect (P = 0.008). The number of cycles for expansion was not significant (P = 0.303) [Table 3].

Based on the site of tissue expansion, the tissue expansion characteristics were compared [Table 4]. There was no significant relationship in terms of number of days (P = 0.091), total volume of tissue expansion fluid (P = 0.075) and volume per cycle (P = 0.873). A borderline difference was seen in the number of cycles (P = 0.06). Table 5 shows the comparison of derived parameters based on the site of expansion. There was no statistical correlation seen with respect to size of defect/days required (P = 0.595) and size of the defect/cycles required (P = 0.745). The rate of expansion, as calculated by total volume/number of cycles, shows that forehead has an average rate of 59.17 ± 16.27, face and cheek has a mean expansion rate of 69.11 ± 30.19 while neck had a rate of 62.6 ± 25.75. The difference was not statistically significant (P = 0.873) [Graph 1]. The rate of expansion, for the burn cases was 75.52 ± 28.41 while for the trauma cases, it was 58.77 ± 23.19. The difference was not statistically significant (P = 0.169).

Table 2: The tissue expansion characteristics compared based on etiology

	n	Mean±SD	*P*
Size of the defect			
Burn	6	3464.50±409.47	0.059
Trauma	8	2622.88±898.54	
Number of days required to complete tissue expansion			
Burn	7	35.83±4.83	0.044
Trauma	11	29.79±6.18	
Total volume of tissue expansion fluid			
Burn	7	420.00±115.04	0.003
Trauma	11	281.82±159.79	
Total number of cycles			
Burn	7	5.93±1.43	0.211
Trauma	11	4.88±1.48	
Volume/cycle			
Burn	7	75.52±28.41	0.211
Trauma	11	58.77±23.19	

SD: Standard deviation

Table 3: Tissue expansion characteristics based on site of defect

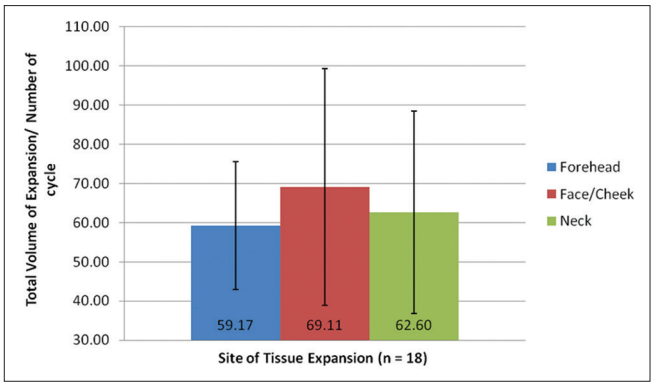
	n	Mean±SD	*P*
Size of the defect			
Nose	5	2323.00±789.07	0.057
Face and cheek	8	3237.38±549.26	
Neck	1	4256.00	
Number of days required to complete			
Nose	5	26.22±2.67	0.011
Face and cheek	8	33.94±3.92	
Neck	1	42.00	
Total volume of tissue expander fluid			
Nose	5	217.00±22.25	0.008
Face and cheek	8	388.75±130.21	
Neck	1	750.00	
Number of cycles of expansion			
Nose	5	5.11±0.52	0.303
Face and cheek	8	5.77±1.37	
Neck	1	8.00	

SD: Standard deviation

Table 4: Tissue expansion characteristics based on the site of expansion

	n	Mean±SD	*P*
Number of days required for tissue expansion			
Forehead	3	25.46±3.01	0.091
Face and cheek	9	32.11±5.32	
Neck	6	35.52±6.78	
Total volume of tissue expander fluid			
Forehead	3	208.33±24.66	0.075
Face and cheek	9	338.89±137.88	
Neck	6	394.17±196.89	
Number of cycles			
Forehead	3	3.73±1.26	0.062
Face and cheek	9	5.17±1.38	
Neck	6	6.25±1.23	
Volume of tissue expander fluid/cycle			
Forehead	3	59.17±16.27	0.873
Face and cheek	9	69.11±30.19	
Neck	6	62.6±25.75	

SD: Standard deviation



Graph 1: Graph depicting comparison of the site of expansion with the rate of expansion

DISCUSSION

The goal of tissue expansion is to create adequate amount of local tissue that matches in color and texture, which would give esthetically pleasing results. In addition, the advancement of local flap ensure adequate blood supply to the region, ensuring proper healing and success of the expanded flap. Owing to expansion, donor site morbidity can also be minimized to a greater extent. Since the time of its inception and advocacy, the technique has not been free from disadvantages [Figures 11-14]. It was a highly sensitive technique and rate of complications were large. Advantages of tissue expansion are (i) No deforming secondary defects; (ii) No distant flaps; (iii) Best color match, texture, hair bearing; (iv) Better vascularity; (v) best survival of the reconstruction. The disadvantages or discomfort include: (i) Frequent office visits for inflation or prolonged stay; (ii) discomfort and; (iii) Deformity during inflation.[1]

There are reports of the craniofacial tissue expanders from institutional setting but none from a private setting. The goal of the present manuscript is to present the experience of craniofacial tissue expansion from this setting in this part of the world. As the current study was performed in a tertiary setting, hospital admission bias is a possibility. But considering the rarity of the technique used in the craniofacial region and the fact that the nonparametric tests being used in this study, the results of this study would serve as a robust estimate for the measured outcomes. In this part of the world, it is not uncommon for females to seek surgical correction more often than males.[6] This is also reflected in the present study. As the other predictor factors such as cause, site and size are attributable to socio-cultural -regional variations they are not discussed in depth. Trauma contributed to greater number of defects (57.1%). The most common defect occurs in face/cheek compartment (57.15%) followed by nose (35.71%). Owing to ease of access and better results, more expanders have been placed in cheek (50%), followed by neck (33.33%). The mean defect size was 2983.58 ± 828.27 mm^2 and it has a mean of 32.14 ± 6.31 days to complete the expansion. The mean total volume of tissue expander fluid used was 335.6 ± 156.51 ml in a mean number of 5.29 ± 1.5 cycles of administration [Table 1].

In the craniofacial region, the laxity of the skin in different areas is markedly different.[7,8] This probably is related to the form, function, and embryology. The degree of laxity is an important factor that would determine the rate of the tissue expansion.[7]

Figure 11: Case 3 – (a and b) Extensive craniofacial defect due to trauma

Figure 13: (a-d) Progressive deformity in neck region after expander placement leading to failure of the technique, device removed and site sutured

Table 5: Comparison of derived parameters based on the site of expansion

	Mean±SD	*P*
Size of defect/days required		
Forehead	69.14±3.01	0.595
Face and cheek	94.19±19.08	
Neck	96.24±25.34	
Size of the defect/cycles		
Forehead	435.39±123.43	0.745
Face and cheek	491.39±172.04	
Neck	472.44±177.30	

SD: Standard deviation

The "pinch test" is often employed to crudely estimate the amount of skin laxity in vertical direction.[9] Applying the same to the forehead/scalp, cheek and Neck region, one could observe that the skin of the cheek and neck are relatively lax than that of the forehead and scalp. When "tissue pockets" are created in such skin and carefully inflated, the biological creep would be much in the face/cheek and neck rather than the forehead unit. Finite element models have predicted the same.[10] The results of the present study are in agreement with the earlier such reports.

Burn scar tissues are reported to be relatively less vascularized and thick than the trauma. Though this is a generalized, vague statement,[11] the aorta of truth in this statement cannot be

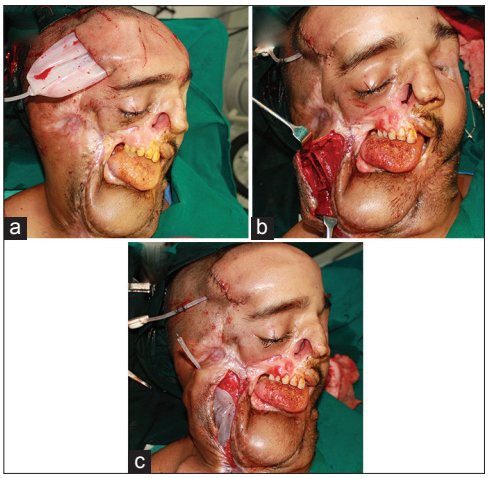


Figure 12: (a-c) Two expanders placed, one each in the forehead and right cheek

Figure 14: (a-c) Deformity in forehead region during inflation due to poor skin laxity leading to failure. Device drained, deflated removed and site sutured

overruled. Large burn scar often turns to be denser, thick with more contractures. Tissue expansion in the area of such dense tissue is challenging. In the present manuscript, burn patients had larger sized defect, required relatively more number of days, more tissue expander fluid and increased number of cycles to complete expansion [Table 2]. However, for none of the parameter there was any statistical significance. The rate of expansion, for the burn cases was 75.52 ± 28.41 while for the trauma cases, it was 58.77 ± 23.19. The difference was not statistically significant (P = 0.169). This further supports this notion.

In the present study, nose required less size of tissue, probably owing to anatomical structure and thereby required less number of days, volume of tissue expansion fluid and less number of cycles of expansion. Depending on the site of the defect, the number of days required to complete tissue expansion (P = 0.011) and total volume of tissue expansion fluid (P = 0.008) were significant [Table 3]. This could be attributed to anatomical compartment requirements and laxity of the donor skin site.[7-10]

On comparing the donor or the expansion site, there was no statistical significance is any of the outcome variable or the derived variables [Tables 4 and 5]. There is no statistical evidence to prove the relationship of number of days required, total volume of fluid, number of cycles, volume/cycle, size of defect/days required and size of defect/cycles. However, there is an observable trend of requiring fewer days, volume of fluid and cycles for forehead expansion. However, this trend lacks statistical significance.

The laxity of skin, in author's experience holds the key to success. The cheek and neck tissues being relatively loose and having a high value in "pinch test" would give a faster result. This has been highlighted by the trend in the Graph 1. The trend indicates that despite having smaller defect, requiring less volume but still the rate of expansion is lowest for the forehead region. The tightness of skin in the scalp and forehead is already known phenomenon.[8] The cheek and neck region closely follows. However, this difference is not statistically significant. This could be due to various factors including smaller sample sizes, other confounding factors and other patient related factors. The outcome of the results of this study has to be treated with caution owing to probable referral bias, often inherent to such studies.

CONCLUSION

The experience of craniofacial tissue expansion from South Indian setting has been reported. The nature of presentation and progression of expansion is much similar to previous published literature. Additionally, it has been identified that the laxity of the skin (of the donor site) is a crucial factor and influences the rate of expansion. It has been shown that cheek and neck are relatively better place for placement of expansion rather than forehead.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflict of interest.

REFERENCES

1. Cunha MS, Nakamoto HA, Herson MR, Faes JC, Gemperli R, Ferreira MC. Tissue expander complications in plastic surgery: A 10-year experience. Rev Hosp Clin Fac Med Sao Paulo 2002;57:93-7.
2. Bauer BS. Tissue expansion. In: Thorne CH, editor. Grabb and Smith's Plastic Surgery. 6th ed. Los Angeles: LWW; 2007. p. 84-90.
3. Handschel J, Schultz S, Depprich RA, Smeets R, Sproll C, Ommerborn MA, *et al.* Tissue expanders for soft tissue reconstruction in the head and neck area – Requirements and limitations. Clin Oral Investig 2013;17:573-8.
4. Dotan L, Icekson M, Yanko-Arzi R, Ofek A, Neuman R, Margulis A. Pediatric tissue expansion: Our experience with 103 expanded flap reconstructive procedures in 41 children. Isr Med Assoc J 2009;11:474-9.
5. Awad MM. The effect of tissue expanders on the growing craniofacial skeleton. Indian J Plast Surg 2006;39:22-8.
6. Hussain S. Evaluation of alveolar grafting with tibial graft in adolescent patients. Indian J Dent Res 2013;24:659-63.
7. Antonyshyn O, Gruss JS, Zuker R, Mackinnon SE. Tissue expansion in head and neck reconstruction. Plast Reconstr Surg 1988;82:58-68.
8. Thomaidis VK. Cutaneous Flaps in Head and Neck Reconstruction: From Anatomy to Surgery. 1st ed. Germany: Springer; 2014. p. 12-340.
9. Urken ML. The submental island flap. In: Urken ML, Cheney ML, Blackweel KE, Harris JR, Hadlock TA, Futran N, editors. Atlas of Regional and Free Flaps for Head and Neck Reconstruction: Flap Harvest and Insetting. 1st ed. USA: Lippincott Williams and Wilkins; 2012. p. 103.
10. Socci L, Pennati G, Gervaso F, Vena P. An axisymmetric computational model of skin expansion and growth. Biomech Model Mechanobiol 2007;6:177-88.
11. Aarabi S, Longaker MT, Gurtner GC. Hypertrophic scar formation following burns and trauma: New approaches to treatment. PLoS Med 2007;4:e234.