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Systematic Review of Tissue Expansion: Utilization in Non-breast Applications

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Background: Tissue expansion is a versatile reconstructive technique providing well-vascularized local tissue. The current literature focuses largely on tissue expansion for breast reconstruction and in the context of burn and pediatric skin/soft tissue replacement; however, less traditional applications are also prevalent. The aim of this study was to systematically review the utilization of tissue expansion in such less well-characterized circumstances.

Methods: The authors conducted a systematic review of all publications describing non-breast applications of tissue expansion. Variables regarding expander specifications, expansion process, and complications were collected and further analyzed.

Results: A total of 565 publications were identified. Of these, 166 publications described tissue expansion for "less traditional" indications, which fell into 5 categories: ear reconstruction, cranioplasty, abdominal wall reconstruction, orthopedic procedures, and genital (penile/scrotal and vaginal/vulva) reconstruction. While lower extremity expansion is known to have high complication rates, tissue expander failure, infection, and exposure rates were in fact highest for penile/scrotal (failure: 18.5%; infection: 15.5%; exposure: 12.5%) and vaginal/vulva (failure: 20.6%; infection: 10.3%; exposure: 6.9%) reconstruction.

Conclusions: Tissue expansion enables index operations by providing additional skin before definitive reconstruction. Tissue expanders are a valuable option along the reconstructive ladder because they obviate the need for free tissue transfer. Although tissue expansion comes with inherent risk, aggregate outcome failures of the final reconstruction are similar to published rates of complications without pre-expansion. Thus, although tissue expansion requires a staged approach, it remains a valuable option in facilitating a variety of reconstructive procedures.
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INTRODUCTION

First introduced in 1957 in the context of ear reconstruction, tissue expansion has evolved as a commonly used reconstructive technique.[1] The advantages of using tissue expanders (TEs) include providing locally sourced vascularized tissue, decreasing donor site morbidity by obviating the need for free tissue transfer, and preserving local skin color, texture, and hair-bearing characteristics. TEs are not without drawbacks: a lengthy process of expansion, the need for multiple operations, and a temporary aesthetic deformity that may not be tolerated.

The current plastic surgery literature provides robust data on utility and outcomes for tissue expansion in the context of breast reconstruction, burn reconstruction, and pediatric skin/soft tissue replacement. This study aimed to provide a similar assessment for less traditional indications for tissue expansion by systematically reviewing studies describing the use of TEs before index operations. Two case examples in which TEs are used to facilitate index operations (1 cranioplasty and 1 orthopedic procedure) are presented.

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METHODS

The databases Medline (National Library of Medicine), Embase (Elsevier), and Scopus (Elsevier) were searched from inception to September 17, 2019. Each database was searched using a combination of keywords to represent the concepts of tissue expansion, surgery, and reconstruction. The full searches are available in SDC 1. (**See appendix, Supplemental Digital Content 1,** which displays the search strategy report. http://links.lww.com/PRSGO/B559.)

The search was supported by a medical librarian. Nonhuman studies, editorials, comments, and conference abstracts were removed from the results when the databases allowed it. Search results were compiled in EndNote and then imported into Covidence. The risk of bias was not assessed.

All English language studies that reported the results of tissue expansion in non-breast reconstruction patients were included. Exclusion criteria included the use of external stretching devices, intraoperative expansion only, and self-filling expanders. The publications were independently screened by 2 reviewers with conflicts broken by the first author (HL).

Studies were then categorized into traditional and less traditional groups. Traditional was defined as studies utilizing TEs for burn reconstruction or skin/soft tissue replacement; less traditional publications encompassed all other applications. For these less traditional indications, we reviewed the patients' age, disease etiology, TE specifications, final TE volume, and the process of tissue expansion. Complications analyzed were TE failure, TE exposure, TE infection, hematoma, wound dehiscence, superficial infection, skin flap necrosis, and any other reported complications. TE failure was defined as any instance in which a TE was removed prematurely. Superficial infection was defined as erythema that was reported to be limited to the skin and not involve the TE, and TE infection was specifically noted in the study to involve the expander. For studies describing traditional indications, we collected information about the indication for TE and number of patients.

RESULTS

After removal of duplicates, 5083 studies were screened and 765 full-texts were reviewed. Of these, 92 were excluded due to the use of interventions such as external or self-filling expanders and to the use of intraoperative expansion only. Eighty-eight were excluded due to the lack of patient-specific outcomes, and 20 were excluded because full-texts could not be located by the reviewers or medical librarian (Fig. 1).

A total of 565 publications were included after full-text review. There were 399 traditional use publications and 166 less traditional use publications. The traditional group included a total of 7767 patients. Patients with TEs for breast reconstruction were excluded in the screening stage and are not included in this review. The most common indication for TE in the traditional group was burn (52.3%), followed by congenital nevi (11.7%) and scar revision (5.0%) (Table 1). The less traditional group included a total of 10,800 patients with ear reconstruction comprising 93.5% (Table 2). Some surgeons use tissue expansion for soft tissue coverage in ear reconstruction, but many others use skin grafts or fascial flaps.[2,3] A 2014 review found that most surgeons use the techniques developed by Nagata and Brent.[4] Given that tissue expansion is only one of many methods utilized during microtia reconstruction, ear reconstruction was included in the less traditional group in this review. Results of the expansion process, TE shape, and complications are summarized in Tables 3–5 and detailed below.

Ear Reconstruction

A total of 44 publications describing 10,101 patients who received a TE before ear reconstruction were included.[5–48] The average age of the patients was 15.3 years (range, 7–41). The indication for ear reconstruction was microtia in 96.5%, trauma in 3.2%, congenital ear deformities other than microtia in 0.28%, and tumor in 0.01%. The plane of expansion was subcutaneous in 37 papers (84.1%), subfascial in 3 (6.8%), dual-plane (subcutaneous and subfascial) in 3 (6.8%), and subgaleal in 1 (2.3%). The average duration of expansion was 2.3 months. Nineteen papers reported a period of static expansion, which is the time when no additional fluid is inserted, on average 4.9 weeks before the index procedure. The average follow-up was 25.7 months. Of the 10,101 patients, 132 (1.3%) had TE failure, 19 (0.19%) TE infection, 127 (1.3%) TE exposure, 196 (1.9%) hematoma, 30 (0.30%) wound dehiscence, 2 (0.020%) superficial infection, and 77 (0.76%) skin flap necrosis. Other reported complications included 289 (2.9%) patients with hypertrophic scarring, 99 (0.98%) framework or suture wire exposure, 21 (0.21%) framework absorption or deformity, 9 (0.089%) TE leakage, 9 (0.089%) framework infection, 7 (0.069%) seroma, 6 (0.059%) skin graft loss, and 4 (0.040%) venous congestion.

Cranioplasty

A total of 14 publications describing 74 patients who received a TE before cranioplasty were included.[49–62] The average age of the patients was 31.6 years (range, 8–55). The indication for cranioplasty was tumor in 32.4%, trauma in 12.2%, epilepsy in 10.8%, vascular cerebral accident in 2.7%, and unspecified in 41.9%. The TE was placed in the subgaleal plane for all patients. The average duration of expansion was 3.6 months. The average follow-up was 22.4 months. Of the 74 patients, 3 (4.1%) had TE failure, 2 (2.7%) TE infection, 2 (2.7%) TE exposure, 1 (1.4%) hematoma, and 1 (1.4%) wound dehiscence. Other reported complications included 6 patients (8.1%) with permanent implant exposure or removal and 1 (1.4%) with seroma.

Abdominal Wall

A total of 30 publications describing 150 patients who received a TE before abdominal wall reconstruction were included.[63–92] The average age of the patients was 26.9 years (range, 3 weeks to 61 years). The indication for abdominal

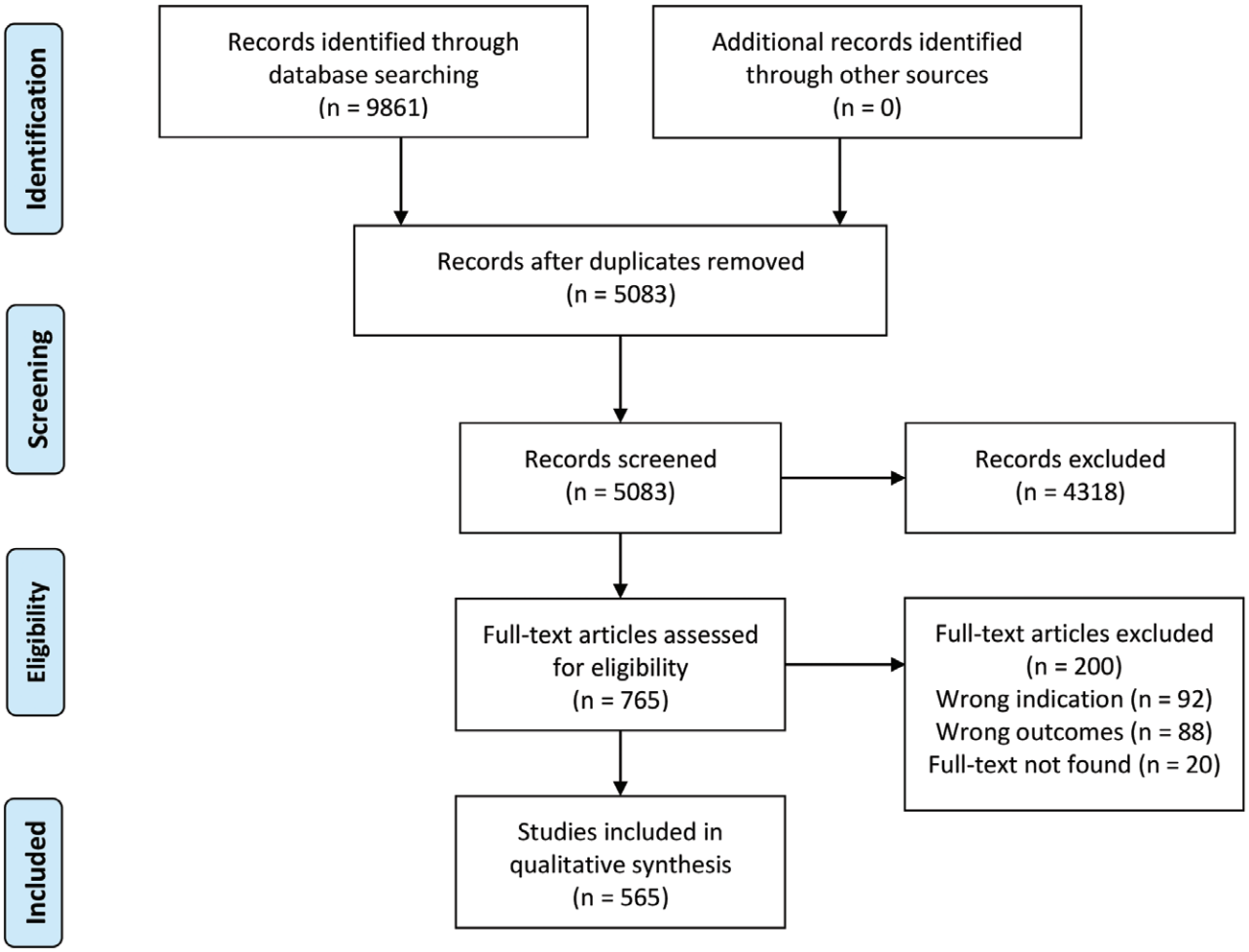

Fig. 1. PRISMA flow diagram of studies included in the systematic review.

wall reconstruction was ventral hernia repair in 82.0% and repair of congenital defects, most commonly omphalocele, in 18.0%. The plane of TE placement was subcutaneous in 15 papers (50%), intermuscular in 8 (26.7%), intra-abdominal in 3 (10.0%), and multiple planes or not specified in 4 (13.3%). The average duration of expansion was 2.8 months. Four papers reported a period of static expansion, on average 9 weeks before the index procedure. The average follow-up was 31.3 months. Of the 150 patients, 8 (5.3%) had a TE failure (6 subcutaneous and 2 intermuscular), 7 (4.7%) TE infection (6 subcutaneous, 1 intermuscular), 4 (2.7%) TE exposure (3 subcutaneous, 1 not specified), 11 (7.3%) hematoma, 4 (2.7%) wound dehiscence, 5 (3.3%) superficial infection, and 1 (0.67%) skin flap necrosis. Other reported complications included 1 patient (0.67%) with enterocutaneous fistula, 1 (0.67%) insufficient skin after expansion for closure, 1 (0.67%) femoral nerve neuropraxia, 2 (1.3%) port failure, and 1 (0.67%) small bowel gangrene. Of the 123 patients who had a ventral hernia repair, 10 (8.1%) had recurrence of the hernia.

Table 1. Indications for Tissue Expansion in the Traditional Group

Indication	% Patients
Burn	52.3
Nevi	11.7
Scar	5.0
Alopecia	2.1
Traumatic wounds	2.1
Pressure ulcers	1.8
AVM	1.4
Cancer	1.4
Skin graft	1.3
Aplasia cutis congenita	0.3
Other	3.2
Not specified	17.3

AVM, arteriovenous malformation.

Table 2. Indications for Tissue Expansion in the Less Traditional Group

Indication	% Patients
Ear reconstruction	93.5
Genital reconstruction	1.9
Penile/scrotal reconstruction	1.6
Vaginal/vulva reconstruction	0.27
Orthopedic reconstruction	1.6
Abdominal wall reconstruction	1.4
Cranioplasty	0.69
Other	1.0

Table 3. Expansion Process before Index Operations

Index Operation	No. Patients	Age (y)	Expander Size (cm^3)	Final Expander Volume (cm^3)	Expansion Begins (POD)	Expansion Frequency (d)	Expansion Duration (mo)
Ear reconstruction	10,101	15.3	71.9	89.7	10.0	4.3	2.3
Cranioplasty	74	31.6	282.9	371.0	16.3	6.5	3.6
Abdominal wall reconstruction	150	26.9	757.7 (VH)	1582.1 (VH)	12.7	5.3	2.8
Orthopedic procedures	170	30.5	327.0	426.7	13.5	6.4	2.2
Penile/scrotal reconstruction	168	30.1	161.1	441.7	15.1	7.1	3.4
Vaginal/vulva reconstruction	29	15.4	149.4	151.7	13.0	8.0	1.8

VH, ventral hernia; POD, postoperative day.

Table 4. Tissue Expander Shape

Index Operation	% Papers Reporting Shape	Rectangular	Round	Kidney	Crescent	Elliptical	Custom
Ear reconstruction	75.0	20.0	5.7	60.0	2.9	11.4	0
Cranioplasty	28.6	50.0	25.0	0	0	0	25.0
Abdominal wall reconstruction	36.7	50.0	21.4	0	21.4	7.1	0
Orthopedic procedures	40.9	44.4	0	0	22.2	11.1	22.2
Penile/scrotal reconstruction	41.2	57.1	42.9	0	0	0	0
Vaginal/vulva reconstruction	30.0	33.3	0	0	33.3	0	33.3

Table 5. Complications for the Less Traditional Group

Index Operation	TE Failure (%)	TE Infection (%)	TE Exposure (%)	Hematoma (%)		Wound Dehiscence (%)		Superficial Infection (%)		Skin Flap Necrosis (%)	
				Total	Expansion Phase	Total	Expansion Phase	Total	Expansion Phase	Total	Expansion Phase
Ear reconstruction	1.3	0.19	1.3	1.9	1.9	0.30	0.28	0.02	0.02	0.76	0.31
Cranioplasty	4.1	2.7	2.7	1.4	0	1.4	0	0	0	0	0
Abdominal wall reconstruction	5.3	4.7	2.7	7.3	5.3	2.7	2.0	3.3	2.7	0.67	0
Orthopedic procedure	10.6	3.5	3.5	2.4	0.59	5.3	4.7	7.1	6.5	4.1	3.5
Penile/scrotal reconstruction	18.5	15.5	12.5	1.2	0.6	3.6	1.2	6.0	0	0.60	0
Vaginal/vulva reconstruction	20.7	10.3	6.9	6.9	0	3.4	3.4	0	0	0	0

Orthopedic Procedures

A total of 22 publications describing 170 patients who received a TE before an orthopedic procedure were included.[93–114] The average age of the patients was 30.5 years (range, 1–76). The indication for orthopedic intervention was total knee arthroplasty in 61.8%, clubfoot in 19.4%, foot and ankle surgery besides clubfoot in 11.8%, kyphoscoliosis in 4.1%, femur pathology in 1.8%, tibial bone grafting in 0.6%, and quadriceps lengthening and patellar re-alignment in 0.59%. The average duration of expansion was 2.2 months. Three of 22 papers reported a period of static expansion, on average 5 weeks before the index procedure. The average follow-up was 21.8 months. Of the 170 patients, 18 (10.6%) had TE failure, 6 (3.5%) TE infection, 6 (3.5%) TE exposure, 4 (2.4%) hematoma, 9 (5.3%) wound dehiscence, 12 (7.1%) superficial infection, and 7 (4.1%) skin flap necrosis. Other reported complications included 3 patients (1.8%) with TE leakage, 2 (1.2%) with TE migration, and 5 (2.9%) with skin blistering.

Genital Reconstruction

Penile/Scrotal Reconstruction

A total of 17 publications describing 168 patients who received a TE before penile or scrotal reconstruction were included.[115–131] The average age of the patients was 30.1 years (range, 3–57). The indication for penile or scrotal reconstruction was hypospadias in 35.7%, transgender surgery in 31.0%, epispadias in 24.4%, trauma in 4.2%, infection in 3.0%, bladder extrophy in 0.59%, cryptorchidism in 0.59%, and congenital adrenal hyperplasia in 0.59%. The average duration of expansion was 3.4 months. One publication reported a period of static expansion of 12 weeks before the index procedure. The average follow-up was 39.0 months. Of the 168 patients, 31 (18.5%) had TE failure, 26 (15.5%) TE infection, 21 (12.5%) TE exposure, 2 (1.2%) hematoma, 6 (3.6%) wound dehiscence, 10 (6.0%) superficial infection, and 1 (0.60%) flap necrosis. Other reported complications included 25 (14.9%) patients with TE leakage, 28 (16.7%) urinary fistula, 5 (3.0%) TE migration, 12 (7.1%) residual chordee, 17 (10.1%) urethral stricture, and 4 (2.4%) port failure. Six of the 60 (10.0%) hypospadias patients had residual hypospadias.

Vaginal/Vulva Reconstruction

A total of 10 publications describing 29 patients who received a TE in a labial or subcutaneous pocket before vaginal or vulva reconstruction were included.[132–141] The average age of the patients was 15.4 years (range, 1–23). The indication for vaginal or vulva reconstruction was a congenital anomaly in all patients, including 65.5% with

congenital vaginal agenesis, 13.8% bladder extrophy, 10.3% congenital adrenal hyperplasia, 3.4% cloacal extrophy, 3.4% urogenital sinus, and 3.4% with utero-vaginal aplasia. The average duration of expansion was 1.8 months. One publication reported a period of static expansion of 3 weeks before the index procedure. The average follow-up was 10.8 months. Of the 29 patients, 6 (20.7%) had TE failure, 3 (10.3%) showed TE infection, 2 (6.9%) had TE exposure, 2 (6.9%) showed hematoma, and 1 (3.4%) had wound dehiscence. The only other reported complication was chronic vaginal stenosis in 1 (3.4%) patient.

Other Indications

A total of 29 publications describing 108 patients who received a TE before a variety of other index operations were included.[72,142–169] Thirty-eight patients underwent tissue expansion before conjoined twin separation, 30 before nasal reconstruction for congenital nasal deformities, 28 prior craniofacial cleft repair, 6 before myelomenigocele repair, 2 before subcutaneous colon interposition, 2 before orbital hypertelorism correction, 1 before agnathia reconstruction, and 1 before esophageal reconstruction. All 5 instances of TE failure among these patients occurred in the context of twin separation.

Case Examples

Patient 1 presented at age 36 after resection of an oligodendroglioma. His postoperative course had been complicated by wound infection necessitating 2 operative debridements and eventual removal of his native bone "flap." He was subsequently referred to Plastic Surgery for consideration of cranioplasty. At the time of initial consult, he had a 20-cm curvilinear left parietal scar (Fig. 2). Given this extensive scalp defect, a 2-stage reconstruction was planned.

During the first stage, a 550 cm^3 rectangular TE was inserted in the frontoparietal scalp and inflated with 50 cm^3 of normal saline. After healing for 3 weeks, he underwent weekly serial expansion for 3 months without complication (Fig. 3). During the second stage, a custom titanium implant was placed to reconstruct the left temporoparietal defect (Fig. 4). For soft tissue reconstruction, a 20 × 30 cm fasciocutaneous scalp flap based on the right superficial temporal and posterior auricular vessels was raised. Next, the left temporoparietal flap that was previously covering the dura was mobilized to create a 12 × 12 cm flap based on the left superficial temporal vasculature. The flaps were then rotated and advanced to sufficiently cover the defect. He is healing well, with no further complications in the 7 months since surgery (Fig. 5).

Patient 2 was involved in a car accident at age 4 that resulted in an open right distal tibia fracture requiring treatment with an external fixator and coverage of a medial ankle defect with a rotational flap and split-thickness skin graft. He presented 1 year after the accident for evaluation of an acquired right ankle deformity and leg length discrepancy. Radiographs demonstrated obliteration of the distal tibia physis with varus deformity of the ankle (Fig. 6). Given the adherent and unstable nature of his skin graft site, he was evaluated by Plastic Surgery and a 2-stage approach was planned. In the first stage, 2 TEs, one 90-cm^3 crescent expander and one 60-cm^3 rectangular expander, were placed in a subfascial plane superior to the grafted wound. After 3 weeks of healing, he underwent weekly serial expansion for 3 months. By the end of expansion, the distal TE was insufflated to 30 cm^3 and the proximal TE was insufflated to 54 cm^3 (Fig. 7).

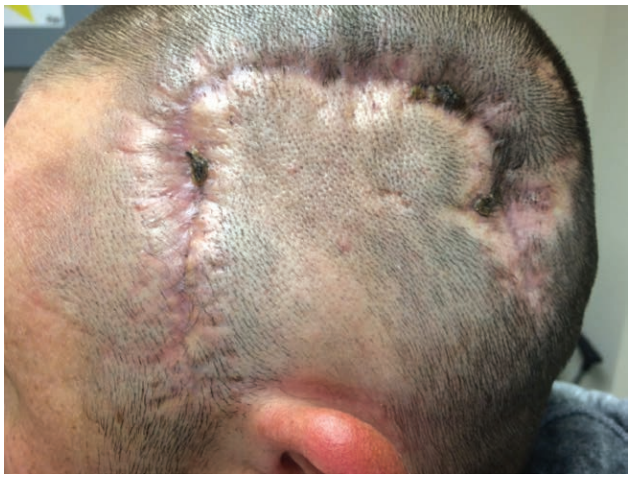

Fig. 2. One month after bone flap removal at initial presentation to plastic surgery.

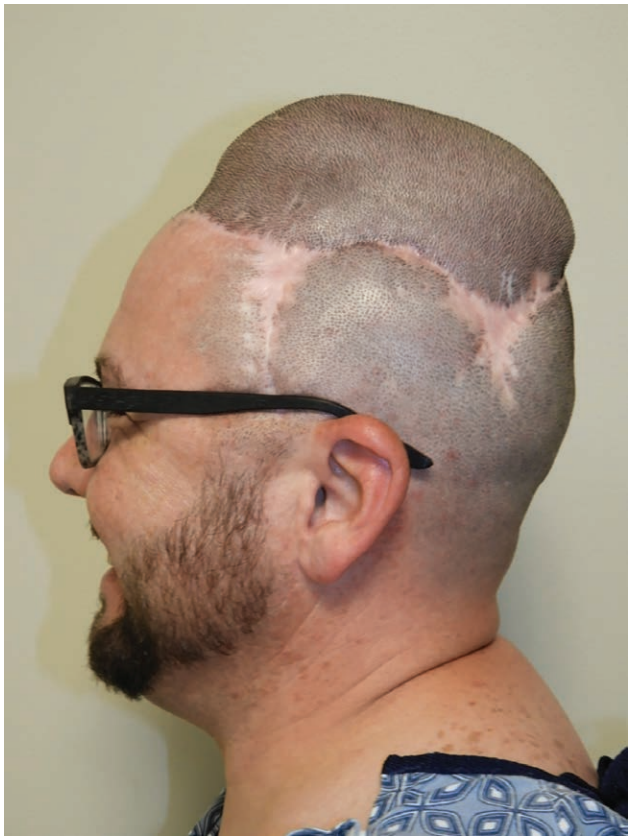

Fig. 3. TE at full expansion.

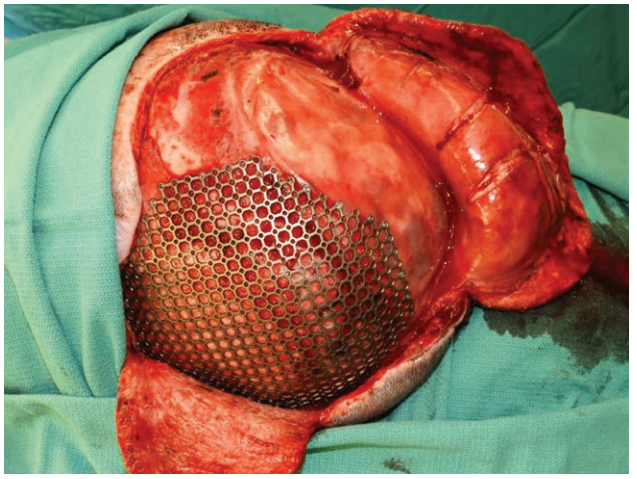

Fig. 4. Inset of custom titanium implant.

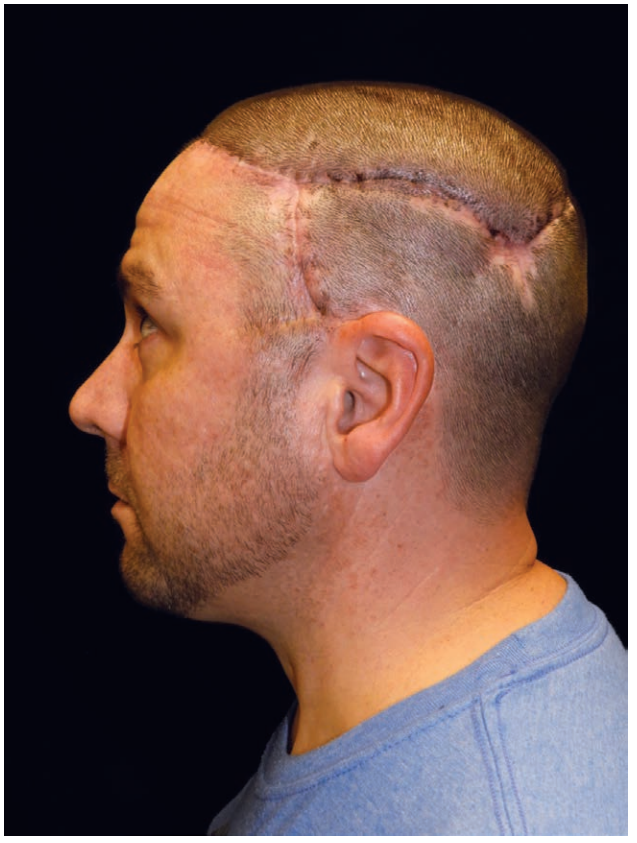

Fig. 5. Result 3 weeks after cranioplasty.

During the second stage, the lower extremity TEs were removed, the unstable, contracted scar was excised, and the expanded flaps were rotated and advanced for closure. Orthopedic surgery performed tibial and fibular osteotomies and applied a spatial frame for later distraction osteogenesis. Eighteen months postoperatively, right ankle radiographs demonstrated proper distraction at the osteotomy site with improved ankle alignment and bone formation. At his 21 months follow-up, he had healed well and ambulates without difficulty (Fig. 8).

DISCUSSION

Tissue expansion provides healthy, well-vascularized skin that can enable reconstruction in any area of the body. Although TEs have been extensively studied in the settings of breast reconstruction, burn reconstruction, and skin lesion excision, there are several less traditional indications that have not been comprehensively reviewed. These indications predominantly fell into 5 major groups: ear reconstruction, cranioplasty, abdominal wall reconstruction, orthopedic procedures, and genital (vaginal/vulvar, and penile/scrotal) reconstruction.

Despite their inherent complications, TEs facilitated the definitive reconstruction in nearly all patients. All cranioplasty patients who were pre-expanded went on to receive their implants. For abdominal wall reconstruction patients, 96.7% successfully underwent the index procedure. Two children died on the organ transplant list and 2 others did not receive reconstruction after attempted expansion.[64,89] In the orthopedic reconstruction group, TE facilitated the index procedure in 96.5% of patients, with 1 patient resorting to a cross-leg flap and 5 abandoning reconstruction.[98,100,104,105,114] All patients who were pre-expanded before ear reconstruction underwent the index operation. In the genital reconstruction groups, TE facilitated the index operation in 95.8% of the scrotal/penile reconstruction patients and 96.6% of the vaginal/vulva reconstruction patients.

Within these 5 categories of index operations, complications varied. Given the contaminated environment of the perineum, it is unsurprising that TE failure rates and TE infection rates were highest for genital reconstruction. Although the 2011 meta-analysis by Huang et al reports that lower extremity TEs are the most likely sites to develop complications, their review did not include genital reconstruction.[170] Thus, although lower extremity TEs are indeed at high risk for complications, this review shows that genital reconstruction is associated with even higher rates of TE complications. Many patients in the cranioplasty, orthopedic, and abdominal wall reconstruction groups had prior failed reconstructions due to infection or implant exposure.[52,53,71,96,103] Despite this inherently high-risk, multiply re-operated cohort, the TE failure, exposure, and infection rates were acceptable, all at <6% for cranioplasty and abdominal wall reconstruction and <11% for orthopedic procedures.

In addition to discussing the risks of TEs, it is important to also consider the outcome of the index operations. Among techniques using autologous cartilage for microtia reconstruction, a recent systematic review found no difference in overall complication rates between pre-expansion (14.18%) and no expansion (22.23%) methods.[171] Although our review encompasses more than autologous microtia reconstruction patients, the overall complication rate in this review of 11.8% supports the assertion that the use of TEs does not increase the overall complication rate. For the cranioplasty group, 8.1% of patients had

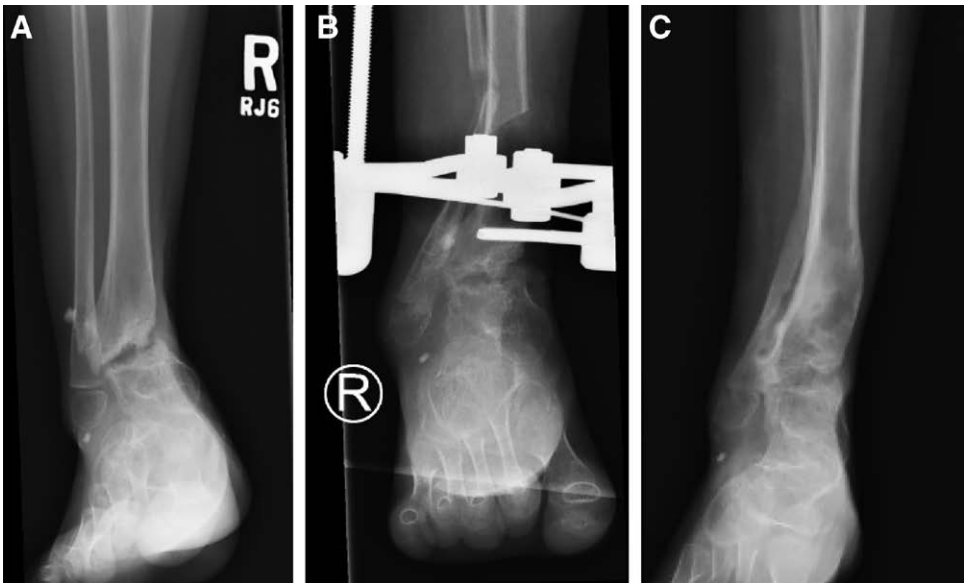

Fig. 6. Anteroposterior (AP) right ankle x-rays (A) at initial presentation, (B) 1 month after tibial and fibular osteotomies, and (C) 17 months after osteotomies.

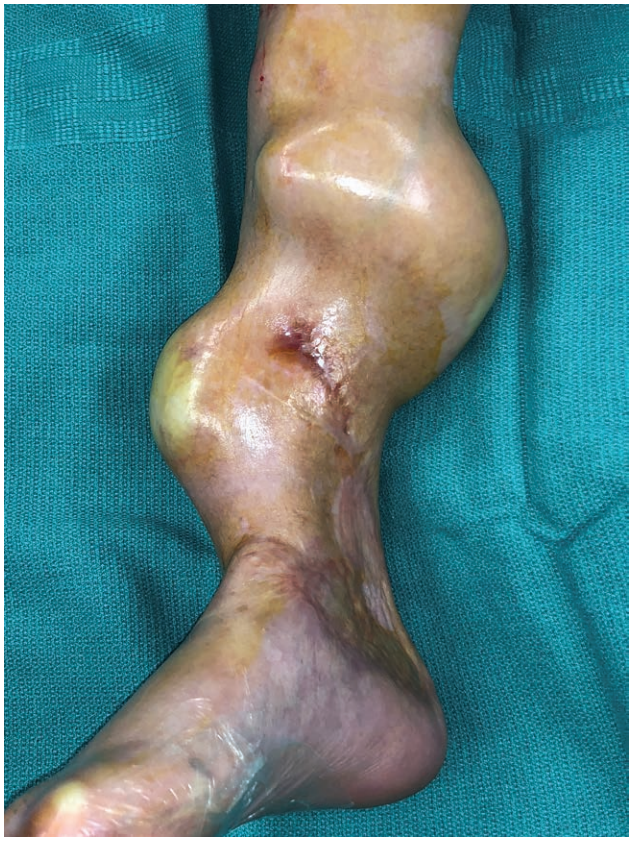

Fig. 7. TEs at full expansion.

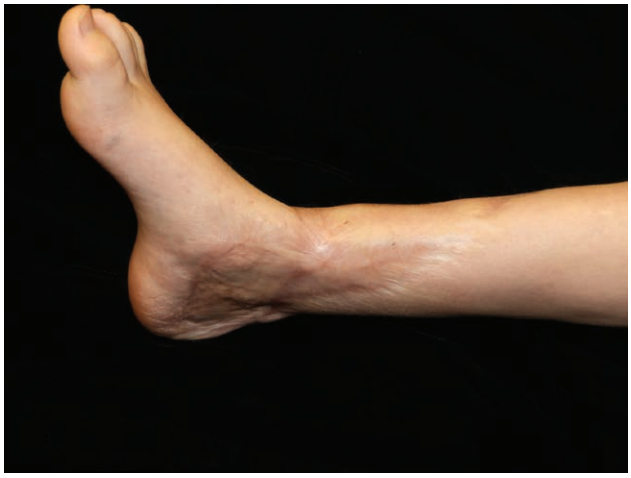

Fig. 8. Result 21 months after orthopedic procedure.

implant exposure or removal. This is similar to the rate of cranioplasty removal (12.8%) reported in a recent large cohort study of primary synthetic cranioplasty patients.[172] Recurrence of hernia after abdominal wall reconstruction using TEs was 8.1%, which is slightly lower than the 11.7% rate of recurrence reported in a 2017 systematic review of these patients, and on the lower end of reported rates of hernia recurrence ranging from 1.4% to 28% after ventral hernia repair without pre-expansion.[173–176] There were no cases of implant failure after orthopedic procedures in our review. It is known that urethral fistulas and strictures are 2 of the most common complications after penile reconstruction, with rates ranging from 5% to 44%.[177–181] The rates of fistula and strictures in this review are within this accepted range at 16.7% and 10.1%, respectively.

There are several limitations to this study. Excluding the ear reconstruction group, the average number of patients per study was 5.7. These case reports or small cohort studies may not accurately capture the true complication rate of these less traditional TE indications. Second, the groups in our review lack homogeneity in terms of patients' disease etiology and specific index procedures,

which prohibited any statistical analysis within the groups. There is also a potential bias given that it was not possible to clearly elucidate and remove duplicate patients. Finally, although outcome failures of the final reconstructive procedure seem to be similar with and without pre-expansion, a cohort study is needed to truly make this conclusion.

CONCLUSIONS

This review assures surgeons and patients that despite inherent TE complications, tissue expansion successfully facilitates the definitive reconstruction in nearly all patients. Surgeons should advise patients that intrinsic TE complications are highest in genital reconstruction, followed by orthopedic procedures, whereas the risk of TE failure is significantly lower in the setting of ear reconstruction, abdominal wall reconstruction, and cranioplasty. Outcome failures of the definitive reconstruction, such as cranioplasty exposure, hernia recurrence, and urinary fistula, are in line with published rates of overall complications without pre-expansion. Thus, although TEs postpone the final reconstruction by 2–3 months, they remain a valuable option along the reconstructive ladder.

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PATIENT CONSENT

The patient provided written consent for the use of his image.

REFERENCES

1. Neumann CG. The expansion of an area of skin by progressive distention of a subcutaneous balloon; use of the method for securing skin for subtotal reconstruction of the ear. *Plast Reconstr Surg (1946)*. 1957;19:124–130.
2. Wilkes GH, Wong J, Guilfoyle R. Microtia reconstruction. *Plast Reconstr Surg*. 2014;134:464e–479e.
3. Baluch N, Nagata S, Park C, et al. Auricular reconstruction for microtia: A review of available methods. *Plast Surg (Oakv)*. 2014;22:39–43.
4. Storck K, Staudenmaier R, Buchberger M, et al. Total reconstruction of the auricle: Our experiences on indications and recent techniques. *Biomed Res Int*. 2014;2014:373286.
5. Chen Q, Zhang J, Wang B, et al. Total auricular reconstruction using a single extended postauricular flap without skin grafting in two stages: Experiences of 106 cases. *Aesthetic Plast Surg*. 2020;44:365–372.
6. Yang M, Jiang H, Zhang Y, et al. A new method using tissue expander makes auricular reconstruction easier. *Clin Otolaryngol*. 2019;44:437–442.
7. Xing W, Wang Y, Qian J, et al. Simultaneous bilateral microtia reconstruction using single-expanded postauricular flap without skin grafting. *Ann Plast Surg*. 2018;81:669–674.
8. Xing W, Kang C, Wang Y, et al. Reconstruction of microtia using a single expanded postauricular flap without skin grafting: Experience of 683 cases. *Plast Reconstr Surg*. 2018;142:170–179.
9. Park JY, Park C. Microtia reconstruction in hemifacial microsomia patients: Three framework coverage techniques. *Plast Reconstr Surg*. 2018;142:1558–1570.
10. Zhang M, Tian X, Shi J, et al. Investigation of microsurgical technique combined with skin flap expansion for ear reconstruction in treating hunter type III congenital microtia. *Ann Plast Surg*. 2017;78:680–683.
11. Qian J, Li Z, Liu T, et al. Auricular reconstruction in hemifacial microsomia with an expanded two-flap method. *Plast Reconstr Surg*. 2017;139:1200–1209.
12. Zhou J, Pan B, Yang Q, et al. Three-dimensional autologous cartilage framework fabrication assisted by new additive manufactured ear-shaped templates for microtia reconstruction. *J Plast Reconstr Aesthet Surg*. 2016;69:1436–1444.
13. Li C, Jiang H, Huang C, et al. A new strategy for total auricular reconstruction using prelamination of an extended retroauricular flap with tissue expansion. *J Plast Reconstr Aesthet Surg*. 2016;69:819–826.
14. Jiafeng L, Jiaming S, Xiaodan L. Auricular reconstruction using a novel three-flap technique improves the auriculocephalic angle. *J Plast Reconstr Aesthet Surg*. 2016;69:1430–1435.
15. Park BY, Im JT, Lim SY, et al. Microtia reconstruction using tissue expanders without skin grafts from groin region. *J Plast Reconstr Aesthet Surg*. 2014;67:1481–1487.
16. Kludt NA, Vu H. Auricular reconstruction with prolonged tissue expansion and porous polyethylene implants. *Ann Plast Surg*. 2014;72(suppl 1):S14–S17.
17. Hu J, Liu T, Zhou X, et al. Treatment of postburn ear defect with expanded upper arm flap and consequent expansion without skin grafting. *Ann Plast Surg*. 2014;72:398–401.
18. Zhou X, Zhang Q, Liu T, et al. Modification in the technique of ear framework fabrication for congenital microtia. *J Craniofac Surg*. 2012;23:1296–1300.
19. Zhang GL, Zhang JM, Liang WQ, et al. Implant double tissue expanders superposingly in mastoid region for total ear reconstruction without skin grafts. *Int J Pediatr Otorhinolaryngol*. 2012;76:1515–1519.
20. Xiaobo Y, Haiyue J, Hongxing Z, et al. Post-traumatic ear reconstruction using postauricular fascial flap combined with expanded skin flap. *J Plast Reconstr Aesthet Surg*. 2011;64:1145–1151.
21. Pearl RA, Sabbagh W. Reconstruction following traumatic partial amputation of the ear. *Plast Reconstr Surg*. 2011;127:621–629.
22. Liu J, Sun J, Li X. Total auricular reconstruction without skin grafting. *J Plast Reconstr Aesthet Surg*. 2011;64:1312–1317.
23. Chen Z, Zhang W, Huang J, et al. Exceedingly expanded retroauricular flaps for microtia reconstruction. *J Plast Reconstr Aesthet Surg*. 2011;64:1448–1453.
24. Zhang Q, Quan Y, Su Y, et al. Expanded retroauricular skin and fascial flap in congenital microtia reconstruction. *Ann Plast Surg*. 2010;64:428–434.
25. Liu X, Zhang Q, Quan Y, et al. Bilateral microtia reconstruction. *J Plast Reconstr Aesthet Surg*. 2010;63:1275–1278.
26. Driscoll DN, Lee JH. Combining scalp tissue expansion with porous polyethylene total ear reconstruction in burned patients. *Ann Plast Surg*. 2010;64:183–186.
27. Zhao Y, Wang Y, Zhuang H, et al. Clinical evaluation of three total ear reconstruction methods. *J Plast Reconstr Aesthet Surg*. 2009;62:1550–1554.
28. Yang SL, Zheng JH, Ding Z, et al. Combined fascial flap and expanded skin flap for enveloping Medpor framework in microtia reconstruction. *Aesthetic Plast Surg*. 2009;33:518–522.
29. Wang Y, Zhuang X, Jiang H, et al. The anatomy and application of the postauricular fascia flap in auricular reconstruction for congenital microtia. *J Plast Reconstr Aesthet Surg*. 2008;61(suppl 1):S70–S76.
30. Pan B, Jiang H, Guo D, et al. Microtia: Ear reconstruction using tissue expander and autogenous costal cartilage. *J Plast Reconstr Aesthet Surg*. 2008;61(suppl 1):S98–103.

31. Jiang H, Pan B, Lin L, et al. Ten-year experience in microtia reconstruction using tissue expander and autogenous cartilage. *Int J Pediatr Otorhinolaryngol.* 2008;72:1251–1259.
32. Dashan Y, Haiyue J, Qinghua Y, et al. Technical innovations in ear reconstruction using a skin expander with autogenous cartilage grafts. *J Plast Reconstr Aesthet Surg.* 2008;61(suppl 1):S59–S69.
33. Jing C, Hong-Xing Z. Partial necrosis of expanding postauricular flaps during auricle reconstruction: Risk factors and effective management. *Plast Reconstr Surg.* 2007;119:1759–1766.
34. Xiaogeng H, Hongxing Z, Qinghua Y, et al. Subtotal ear reconstruction for correction of type 3 constricted ears. *Aesthetic Plast Surg.* 2006;30:455–459.
35. Park C, Mun HY. Use of an expanded temporoparietal fascial flap technique for total auricular reconstruction. *Plast Reconstr Surg.* 2006;118:374–382.
36. Chiang YC. Combined tissue expansion and prelamination of forearm flap in major ear reconstruction. *Plast Reconstr Surg.* 2006;117:1292–1295.
37. Kaneko T, Takano J, Kobayashi M, et al. Computer-aided surgery and tissue expansion in auricular reconstruction for microtia. *Keio J Med.* 2001;50(suppl 2):109–119.
38. Park C. Subfascial expansion and expanded two-flap method for microtia reconstruction. *Plast Reconstr Surg.* 2000;106:1473–1487.
39. Hata Y, Umeda T. Reconstruction of congenital microtia by using a tissue expander. *J Med Dent Sci.* 2000;47:105–116.
40. Park C. Lower auricular malformations: Their representation, correction, and embryologic correlation. *Plast Reconstr Surg.* 1999;104:29–40.
41. Harris PA, Ladhani K, Das-Gupta R, et al. Reconstruction of acquired sub-total ear defects with autologous costal cartilage. *Br J Plast Surg.* 1999;52:268–275.
42. Chana JS, Grobbelaar AO, Gault DT. Tissue expansion as an adjunct to reconstruction of congenital and acquired auricular deformities. *Br J Plast Surg.* 1997;50:456–462.
43. Kaneko T. A system for three-dimensional shape measurement and its application in microtia ear reconstruction. *Keio J Med.* 1993;42:22–40.
44. Quaba A. Reconstruction of a posttraumatic ear defect using tissue expansion: 30 years after Neumann. *Plast Reconstr Surg.* 1988;82:521–524.
45. Nordström RE, Salo HP, Rintala AE. Auricle reconstruction with the help of tissue expansion. *Facial Plast Surg.* 1988;5:338–346.
46. Oneal RM, Rohrich RJ, Izenberg PH. Skin expansion as an adjunct to reconstruction of the external ear. *Br J Plast Surg.* 1984;37:517–519.
47. Pan B, Jiang H, Zhao Y, et al. Clinical analysis, repair and aetiology of question mark ear. *J Plast Reconstr Aesthet Surg.* 2010;63:28–35.
48. Zou YH, Zhuang HX, Wang SJ, et al. Satisfactory surgical option for congenital microtia with defects of external auditory meatus (EAM) and middle ear. *Acta Otolaryngol.* 2007;127:705–710.
49. Akamatsu T, Hanai U, Kobayashi M, et al. Cranial reconstruction in a pediatric patient using a tissue expander and custom-made hydroxyapatite implant. *Tokai J Exp Clin Med.* 2015;40:76–80.
50. Lin AY, Kinsella CR Jr, Rottgers SA, et al. Custom porous polyethylene implants for large-scale pediatric skull reconstruction: Early outcomes. *J Craniofac Surg.* 2012;23:67–70.
51. Konofaos P, Thompson RH, Wallace RD. Long-term outcomes with porous polyethylene implant reconstruction of large craniofacial defects. *Ann Plast Surg.* 2017;79:467–472.
52. Sari R, Tonge M, Bolukbasi FH, et al. Management of failed cranioplasty. *Turk Neurosurg.* 2017;27:201–207.
53. Mundinger GS, Latham K, Friedrich J, et al. Management of the repeatedly failed cranioplasty following large postdecompressive craniectomy: Establishing the efficacy of staged free latissimus dorsi transfer/tissue expansion/custom polyetheretherketone implant reconstruction. *J Craniofac Surg.* 2016;27:1971–1977.
54. de Moraes SLC, Afonso AMP, Santos RGD, et al. Reconstruction of the cranial vault contour using tissue expander and castor oil prosthesis. *Craniomaxillofac Trauma Reconstr.* 2017;10:216–224.
55. Merlino G, Carlucci S. Role of systematic scalp expansion before cranioplasty in patients with craniectomy defects. *J Craniomaxillofac Surg.* 2015;43:1416–1421.
56. Carloni R, Hersant B, Bosc R, et al. Soft tissue expansion and cranioplasty: For which indications? *J Craniomaxillofac Surg.* 2015;43:1409–1415.
57. Kasper EM, Ridgway EB, Rabie A, et al. Staged scalp soft tissue expansion before delayed allograft cranioplasty: A technical report. *Neurosurgery.* 2012;71(1 suppl operative):15–20; discussion 21.
58. Dos Santos Rubio EJ, Bos EM, Dammers R, et al. Two-stage cranioplasty: Tissue expansion directly over the craniectomy defect prior to cranioplasty. *Craniomaxillofac Trauma Reconstr.* 2016;9:355–360.
59. Tringali G, D'Ammando A, Bono B, et al. Two-staged frontal bone defect reconstruction: Perioperative assessment of scalp vascularization using near-infrared indocyanine green video angiography (Visionsense iridium). *World Neurosurg.* 2019;126:502–507.
60. Zhai Z, Yu L, Ren T, et al. Use of vacuum-assisted wound closure and tissue expansion in revision cranioplasty for a large-sized composite defect in a child. *J Craniofac Surg.* 2019;30:838–840.
61. Miyazawa T, Azuma R, Nakamura S, et al. Usefulness of scalp expansion for cranioplasty in a case with postinfection large calvarial defect: A case report. *Surg Neurol.* 2007;67:291–295.
62. Williams S, Kang N. Tissue expansion in cranioplasty – a collaborative approach for all involved for improved outcomes. *J Plast Reconstr Aesthet Surg.* 2018;71:1097–1100.
63. Adetayo OA, Aka AA, Ray AO. The use of intra-abdominal tissue expansion for the management of giant omphaloceles: Review of literature and a case report. *Ann Plast Surg.* 2012;69:104–108.
64. Admire AA, Dolich MO, Sisley AC, et al. Massive ventral hernias: Role of tissue expansion in abdominal wall restoration following abdominal compartment syndrome. *Am Surg.* 2002;68:491–496.
65. Alhan D, Şahin İ, Güzey S, et al. Staged repair of severe open abdomens due to high-energy gunshot injuries with early vacuum pack and delayed tissue expansion and dual-sided meshes. *Ulus Travma Acil Cerrahi Derg.* 2015;21:457–462.
66. Alleyne B, Ozturk CN, Rampazzo A, et al. Combined submuscular tissue expansion and anterior component separation technique for abdominal wall reconstruction: Long-term outcome analysis. *J Plast Reconstr Aesthet Surg.* 2017;70:752–758.
67. Bath AS, Patnaik PK, Bhandari PS. Reconstruction of complex abdominal wall defects. *Med J Armed Forces India.* 2007;63:123–126.
68. Bax NM, van der Zee DC, Pull ter Gunne AJ, et al. Treatment of giant omphalocele by enlargement of the abdominal cavity with a tissue expander. *J Pediatr Surg.* 1993;28:1181–1184.
69. Byrd HS, Hobar PC. Abdominal wall expansion in congenital defects. *Plast Reconstr Surg.* 1989;84:347–352.
70. Carlson GW, Elwood E, Losken A, et al. The role of tissue expansion in abdominal wall reconstruction. *Ann Plast Surg.* 2000;44:147–153.
71. Carr JA. Tissue expander-assisted ventral hernia repair for the skin-grafted damage control abdomen. *World J Surg.* 2014;38:782–787.
72. Clifton MS, Heiss KF, Keating JJ, et al. Use of tissue expanders in the repair of complex abdominal wall defects. *J Pediatr Surg.* 2011;46:372–377.
73. Ersoy YE, Celebi F, Erozgen F, et al. Repair of a postappendectomy massive ventral hernia using tissue expanders. *J Korean Surg Soc.* 2013;84:61–65.
74. Gökalan Kara I, Erdem E, Neşşar, M. Reconstruction of large abdominal wall defects. *Eur J Plast Surg.* 1999;22:294–396.

75. Hobar PC, Rohrich RJ, Byrd HS. Abdominal-wall reconstruction with expanded musculofascial tissue in a posttraumatic defect. *Plast Reconstr Surg.* 1994;94:379–383.
76. Howdieshell TR, Proctor CD, Sternberg E, et al. Temporary abdominal closure followed by definitive abdominal wall reconstruction of the open abdomen. *Am J Surg.* 2004;188:301–306.
77. Jacobsen WM, Petty PM, Bite U, et al. Massive abdominal-wall hernia reconstruction with expanded external/internal oblique and transversalis musculofascia. *Plast Reconstr Surg.* 1997;100:326–335.
78. Livingston DH, Sharma PK, Glantz AI. Tissue expanders for abdominal wall reconstruction following severe trauma: Technical note and case reports. *J Trauma.* 1992;32:82–86.
79. Marin-Gutzke M, Mirelis E, Sanchez-Olaso A, et al. Restoring the abdominal cavity space by intraabdominal and extraabdominal tissue expansion. *Plast Reconstr Surg.* 2008;121:359–360.
80. Matthews MS. Abdominal wall reconstruction with an expanded rectus femoris flap. *Plast Reconstr Surg.* 1999;104:183–186.
81. Paletta CE, Huang DB, Dehghan K, et al. The use of tissue expanders in staged abdominal wall reconstruction. *Ann Plast Surg.* 1999;42:259–265.
82. Patel KB, Vu H, Owens V. Tissue expander reconstruction of centrifugal lipodystrophy of the abdominal wall. *Plast Reconstr Surg.* 2010;126:150e–151e.
83. Rodriguez ED, Bluebond-Langner R, Silverman RP, et al. Abdominal wall reconstruction following severe loss of domain: The R Adams Cowley shock trauma center algorithm. *Plast Reconstr Surg.* 2007;120:669–680.
84. Tauber DMP, A. Repair of recurrent ventral hernias using tissue expansion and porcine acellular dermal matrix. *Eur J Plast Surg.* 2013;36:237–246.
85. Tenenbaum MJ, Foglia RP, Becker DB, et al. Treatment of giant omphalocele with intraabdominal tissue expansion. *Plast Reconstr Surg.* 2007;120:1564–1567.
86. Tran NV, Petty PM, Bite U, et al. Tissue expansion-assisted closure of massive ventral hernias. *J Am Coll Surg.* 2003;196:484–488.
87. Vargo JD, Larsen MT, Pearson GD. Component separation technique for repair of massive abdominal wall defects at a pediatric hospital. *Ann Plast Surg.* 2016;77:555–559.
88. Verlende P, Zoltie N. A new surgical approach to exomphalos. *Br J Plast Surg.* 1990;43:241–243.
89. Vidyadharan R, van Bommel AC, Kuti K, et al. Use of tissue expansion to facilitate liver and small bowel transplant in young children with contracted abdominal cavities. *Pediatr Transplant.* 2013;17:646–652.
90. Weiner J, Wu J, Martinez M, et al. The use of bi-planar tissue expanders to augment abdominal domain in a pediatric intestinal transplant recipient. *Pediatr Transplant.* 2014;18:E174–E179.
91. Watson MJ, Kundu N, Coppa C, et al. Role of tissue expanders in patients with loss of abdominal domain awaiting intestinal transplantation. *Transpl Int.* 2013;26:1184–1190.
92. Okunski WJ, Sonntag BV, Murphy RX Jr. Staged reconstruction of abdominal wall defects after intra-abdominal catastrophes. *Ann Plast Surg.* 1996;36:475–478.
93. Arnell K. Primary and secondary tissue expansion gives high quality skin and subcutaneous coverage in children with a large myelomeningocele and kyphosis. *Acta Neurochir (Wien).* 2006;148:293–7; discussion 297.
94. Atar D, Grant AD, Silver L, et al. The use of a tissue expander in club-foot surgery. A case report and review. *J Bone Joint Surg Br.* 1990;72:574–577.
95. Cho SH, Jeong ST, Park HB, et al. Two-stage conversion of fused knee to total knee arthroplasty. *J Arthroplasty.* 2008;23:476–479.
96. Gold DA, Scott SC, Scott WN. Soft tissue expansion prior to arthroplasty in the multiply-operated knee. A new method of preventing catastrophic skin problems. *J Arthroplasty.* 1996;11:512–521.
97. Hamnett NT, Mishra A, Nayagam S, et al. Preexpanded muscle-sparing latissimus dorsi free flap in complex lower limb trauma: The orthoplastic approach. *Plast Reconstr Surg.* 2010;126:211e–213e.
98. Long WJ, Wilson CH, Scott SM, et al. 15-year experience with soft tissue expansion in total knee arthroplasty. *J Arthroplasty.* 2012;27:362–367.
99. Mahomed N, McKee N, Solomon P, et al. Soft-tissue expansion before total knee arthroplasty in arthrodesed joints. A report of two cases. *J Bone Joint Surg Br.* 1994;76:88–90.
100. Manifold SG, Cushner FD, Craig-Scott S, et al. Long-term results of total knee arthroplasty after the use of soft tissue expanders. *Clin Orthop Relat Res.* 2000;(380):133–139.
101. Möller M, Karlsson J, Lind K, et al. Tissue expansion for repair of severely complicated Achilles tendon ruptures. *Knee Surg Sports Traumatol Arthrosc.* 2001;9:228–232.
102. Mustoe TA, Gifford GH, Lach E. Rapid tissue expansion in the treatment of myelomeningocele. *Ann Plast Surg.* 1988;21:70–73.
103. Namba RS, Diao E. Tissue expansion for staged reimplantation of infected total knee arthroplasty. *J Arthroplasty.* 1997;12:471–474.
104. Nickel KJ, Van Slyke AC, Knox AD, et al. Tissue expansion for severe foot and ankle deformities: A 16-year review. *Plast Surg (Oakv).* 2018;26:244–249.
105. Paletta C, Campbell E, Shehadi SI. Tissue expanders in children. *J Pediatr Surg.* 1991;26:22–25.
106. Persson BM, Broomé A. Lengthening a short femoral amputation stump. A case of tissue expander and endoprosthesis. *Acta Orthop Scand.* 1994;65:99–100.
107. Roposch A, Steinwender G, Linhart WE. Implantation of a soft-tissue expander before operation for club foot in children. *J Bone Joint Surg Br.* 1999;81:398–401.
108. Rosselli P, Reyes R, Medina A, et al. Use of a soft tissue expander before surgical treatment of clubfoot in children and adolescents. *J Pediatr Orthop.* 2005;25:353–356.
109. Santore RF, Kaufman D, Robbins AJ, et al. Tissue expansion prior to revision total knee arthroplasty. *J Arthroplasty.* 1997;12:475–478.
110. Save AV, Wiznia DH, Wang M, et al. The use of soft tissue expanders prior to total ankle arthroplasty. *Foot Ankle Spec.* 2017;10:473–479.
111. Silver L, Grant AD, Atar D, et al. Use of tissue expansion in clubfoot surgery. *Foot Ankle.* 1993;14:117–122.
112. Weinzweig N, Dowden RV, Stulberg BN. The use of tissue expansion to allow reconstruction of the knee. A case report. *J Bone Joint Surg Am.* 1987;69:1238–1240.
113. Cole WG, Bennett CS, Perks AG, et al. Tissue expansion in the lower limbs of children and young adults. *J Bone Joint Surg Br.* 1990;72:578–580.
114. Bassett GS, Mazur KU, Sloan GM. Soft-tissue expander failure in severe equinovarus foot deformity. *J Pediatr Orthop.* 1993;13:744–748.
115. Atik B, Tan O, Ceylan K, et al. Reconstruction of wide scrotal defect using superthin groin flap. *Urology.* 2006;68:419–422.
116. D'Arpa S, Colebunders B, Stillaert F, et al. Pre-expanded anterolateral thigh perforator flap for phalloplasty. *Clin Plast Surg.* 2017;44:129–141.
117. Dong L, Dong Y, He L, et al. Penile reconstruction by preexpanded free scapular flap in severely burned patient. *Ann Plast Surg.* 2014;73(suppl 1):S27–S30.
118. Elfering L, van der Sluis WB, Bouman MB, et al. Preexpansion in phalloplasty patients: Is it effective? *Ann Plast Surg.* 2019;83:687–692.
119. Fatih Doğan TE, Altıparmak M, Özyazgan İ. Bilateral super thin groin island flap for penile, scrotal, and pubic reconstruction after Fournier's gangrene. *Eur J Plast Surg.* 2011;34:497–499.

120. Kajbafzadeh AM, Sina A, Payabvash S. Management of multiple failed repairs of the phallus using tissue expanders: Long-term postpubertal results. *J Urol.* 2007;177:1872–1877.
121. Mir T, Simpson RL, Hanna MK. The use of tissue expanders for resurfacing of the penis for hypospadias cripples. *Urology.* 2011;78:1424–1429.
122. Murat Çakmak İV, Soyer T, Çavuşoğlu T, et al. The use of tissue expander in the management of staged proximal hypospadias repair: Report of case. *Eur J Plast Surg.* 2012;35:253–255.
123. Di Giuseppe FVP, Ajmar R, Beretta G, et al. Penoscrotal skin avulsion. *Eur J Plast Surg.* 1995;13:305–307.
124. Rapp DE, Cohn AB, Gottlieb LJ, et al. Use of tissue expansion for scrotal sac reconstruction after scrotal skin loss. *Urology.* 2005;65:1216–1218.
125. Rochlin DH, Zhang K, Gearhart JP, et al. Utility of tissue expansion in pediatric phallic reconstruction: A 10-year experience. *J Pediatr Urol.* 2014;10:142–147.
126. Sengezer M, Sadove RC. Scrotal construction by expansion of labia majora in biological female transsexuals. *Ann Plast Surg.* 1993;31:372–376.
127. Shenaq SM, Dinh TA. Total penile and urethral reconstruction with an expanded sensate lateral arm flap: Case report. *J Reconstr Microsurg.* 1989;5:245–248.
128. Solinc M, Kosutic D, Stritar A, et al. Preexpanded radial forearm free flap for one-stage total penile reconstruction in female-to-male transsexuals. *J Reconstr Microsurg.* 2009;25:395–398.
129. Still EF II, Goodman RC. Total reconstruction of a two-compartment scrotum by tissue expansion. *Plast Reconstr Surg.* 1990;85:805–7; discussion 808.
130. Terrier JÉ, Courtois F, Ruffion A, et al. Surgical outcomes and patients' satisfaction with suprapubic phalloplasty. *J Sex Med.* 2014;11:288–298.
131. Van Eeckhout GP, Vanmierlo B, Sen MK, et al. A new technique of expanding the underdeveloped scrotum. *Plast Reconstr Surg.* 2010;126:101e–102e.
132. Fogarty BJ, Harper A, Dornan J, et al. Tissue expansion vaginoplasty: Modified reconstruction following extrusion of the expander. *BJOG.* 2000;107:1042–1046.
133. Belloli G, Campobasso P, Musi L. Labial skin-flap vaginoplasty using tissue expanders. *Pediatr Surg Int.* 1997;12:168–171.
134. Schaeffer CS, King LR, Levin LS. Use of the expanded thoracoepigastric myocutaneous flap in the closure of cloacal exstrophy. *Plast Reconstr Surg.* 1996;97:1479–1484.
135. Chudacoff RM, Alexander J, Alvero R, et al. Tissue expansion vaginoplasty for treatment of congenital vaginal agenesis. *Obstet Gynecol.* 1996;87(5 Pt 2):865–868.
136. Eid JF, Rosenberg P, Rothaus K, et al. Use of tissue expanders in final reconstruction of infrapubic midline scar, mons pubis, and vulva after bladder exstrophy repair. *Urology.* 1993;41:426–430.
137. Patil U, Hixson FP. The role of tissue expanders in vaginoplasty for congenital malformations of the vagina. *Br J Urol.* 1992;70:554–557.
138. Gordon DJ, Millar R, Harley JM. The use of a tissue expansion technique in the reconstruction of the female genitalia in bladder exstrophy. *Br J Obstet Gynaecol.* 1992;99:771–772.
139. Atabay K, Cenetoglu S, Aydogdu M, et al. Vulva reconstruction with a tissue expander. *Plast Reconstr Surg.* 1992;90:520–523.
140. Lilford RJ, Sharpe DT, Thomas DF. Use of tissue expansion techniques to create skin flaps for vaginoplasty. Case report. *Br J Obstet Gynaecol.* 1988;95:402–407.
141. Johnson N, Batchelor A, Lilford RJ. Experience with tissue expansion vaginoplasty. *Br J Obstet Gynaecol.* 1991;98:564–568.
142. Bhandari PS. Simultaneous and symmetrical reconstruction of heminose and restoration of nasal airway in congenital absence of heminose. *Br J Plast Surg.* 2004;57:575–578.
143. Brusati R, Colletti G. The role of maxillary osteotomy in the treatment of arhinia. *J Oral Maxillofac Surg.* 2012;70:e361–e368.
144. Goh KY. Separation surgery for total vertical craniopagus twins. *Childs Nerv Syst.* 2004;20:567–575.
145. Hilfiker ML, Hart M, Holmes R, et al. Expansion and division of conjoined twins. *J Pediatr Surg.* 1998;33:768–770.
146. Holmes AD, Lee SJ, Greensmith A, et al. Nasal reconstruction for maxillonasal dysplasia. *J Craniofac Surg.* 2010;21:543–551.
147. Ishida K. Successful reconstruction of agnathia by intraoral expansion and free vascularized fibula flap. *J Craniofac Surg.* 2019;30:581–583.
148. Jackson OA, Low DW, Larossa D. Conjoined twin separation: Lessons learned. *Plast Reconstr Surg.* 2012;129:956–963.
149. Kashimura T, Nakazawa H, Shimoda K, et al. Successful management of the cervicothoracic esophagus reconstruction by expanded skin flap. *Ann Thorac Surg.* 2014;98:2211–2213.
150. Kent MS, Gayle L, Hoffman L, et al. A new technique of subcutaneous colon interposition. *Ann Thorac Surg.* 2005;80:2384–2386.
151. Liu DL, Shan L, Yuan Q, et al. Refinement of the correction of orbital hypertelorism. *J Craniofac Surg.* 2011;22:217–219.
152. Losee JE, Natali M, Grunwaldt L, et al. Induced restrictive lung disease secondary to tissue expansion in ischiopagus conjoined twins. *Plast Reconstr Surg.* 2009;123:1378–1383.
153. Menard RM, Moore MH, David DJ. Tissue expansion in the reconstruction of Tessier craniofacial clefts: A series of 17 patients. *Plast Reconstr Surg.* 1999;103:779–786.
154. Moore MH, Trott JA, David DJ. Soft tissue expansion in the management of the rare craniofacial clefts. *Br J Plast Surg.* 1992;45:155–159.
155. Mowatt DJ, Thomson DN, Dunaway DJ. Tissue expansion for the delayed closure of large myelomeningoceles. *J Neurosurg.* 2005;103(suppl 6):544–548.
156. Mühlbauer W, Schmidt A, Fairley J. Simultaneous construction of an internal and external nose in an infant with arhinia. *Plast Reconstr Surg.* 1993;91:720–725.
157. Ozgür FF, Kocabalkan O, Gürsu KG. Tissue expansion in median facial cleft reconstruction: A case report. *Int J Oral Maxillofac Surg.* 1994;23:137–139.
158. Rhodes JL, Yacoe M. Preoperative planning for the separation of omphalopagus conjoined twins-the role of a multicomponent medical model. *J Craniofac Surg.* 2013;24:175–177.
159. Spitz L, Capps SN, Kiely EM. Xiphoomphaloischiopagus tripus conjoined twins: Successful separation following abdominal wall expansion. *J Pediatr Surg.* 1991;26:26–29.
160. Spitz L, Stringer MD, Kiely EM, et al. Separation of brachiothoraco-omphalo-ischiopagus bipus conjoined twins. *J Pediatr Surg.* 1994;29:477–481.
161. Staffenberg DA, Goodrich JT. Separation of craniopagus conjoined twins with a staged approach. *J Craniofac Surg.* 2012;23(7 suppl 1):2004–2010.
162. Sun J, Zhang Y, Ruan Q, et al. Gains from the separation of two cases of conjoined twins. *J Plast Reconstr Aesthet Surg.* 2008;61:552–556.
163. Toth BA, Glafkides MC, Wandel A. The role of tissue expansion in the treatment of atypical facial clefting. *Plast Reconstr Surg.* 1990;86:119–122.
164. Webster HR, Marshall DR. Nasal augmentation in chondrodysplasia punctata using tissue expansion. *Br J Plast Surg.* 1991;44:384–385.
165. Wu S, Guo K, Xiao P, et al. Body wall reconstruction for conjoined twins: Our experience and lessons learned. *Ann Plast Surg.* 2018;81(6S suppl 1):S66–S70.
166. Yokomori K, Ohkura M, Kitano Y, et al. Comprehensive planning of operative strategy for separation of ischiopagus tripus twins with particular reference to quality of life. *J Pediatr Surg.* 1993;28:833–837.

167. Zubowicz VN, Ricketts R. Use of skin expansion in separation of conjoined twins. *Ann Plast Surg.* 1988;20:272–276.
168. Zuker RM, Filler RM, Lalla R. Intra-abdominal tissue expansion: An adjunct in the separation of conjoined twins. *J Pediatr Surg.* 1986;21:1198–1200.
169. Ostby E, Inman J, Ardeshirpour F. Use of tissue expander for contracted scarred saddle deformity rhinoplasty. *Facial Plast Surg.* 2019;35:68–72.
170. Huang X, Qu X, Li Q. Risk factors for complications of tissue expansion: A 20-year systematic review and meta-analysis. *Plast Reconstr Surg.* 2011;128:787–797.
171. Long X, Yu N, Huang J, et al. Complication rate of autologous cartilage microtia reconstruction: A systematic review. *Plast Reconstr Surg Glob Open.* 2013;1:e57.
172. Still M, Kane A, Roux A, et al. Independent factors affecting postoperative complication rates after custom-made porous hydroxyapatite cranioplasty: A single-center review of 109 cases. *World Neurosurg.* 2018;114:e1232–e1244.
173. Wooten KE, Ozturk CN, Ozturk C, et al. Role of tissue expansion in abdominal wall reconstruction: A systematic evidence-based review. *J Plast Reconstr Aesthet Surg.* 2017;70:741–751.
174. Warren JA, McGrath SP, Hale AL, et al. Patterns of recurrence and mechanisms of failure after open ventral hernia repair with mesh. *Am Surg.* 2017;83:1275–1282.
175. Muse TO, Zwischenberger BA, Miller MT, et al. Outcomes after ventral hernia repair using the rives-stoppa, endoscopic, and open component separation techniques. *Am Surg.* 2018;84:433–437.
176. Poruk KE, Farrow N, Azar F, et al. Effect of hernia size on operative repair and post-operative outcomes after open ventral hernia repair. *Hernia.* 2016;20:805–810.
177. Wood HM, Kay R, Angermeier KW, et al. Timing of the presentation of urethrocutaneous fistulas after hypospadias repair in pediatric patients. *J Urol.* 2008;180(suppl 4):1753–1756.
178. Kim SK, Moon JB, Heo J, et al. A new method of urethroplasty for prevention of fistula in female-to-male gender reassignment surgery. *Ann Plast Surg.* 2010;64:759–764.
179. Fang RH, Kao YS, Ma S, et al. Phalloplasty in female-to-male transsexuals using free radial osteocutaneous flap: A series of 22 cases. *Br J Plast Surg.* 1999;52:217–222.
180. Monstrey S, Hoebeke P, Selvaggi G, et al. Penile reconstruction: Is the radial forearm flap really the standard technique? *Plast Reconstr Surg.* 2009;124:510–518.
181. Ascha M, Massie JP, Morrison SD, et al. Outcomes of single stage phalloplasty by pedicled anterolateral thigh flap versus radial forearm free flap in gender confirming surgery. *J Urol.* 2018;199:206–214.