Tissue expansion techniques in reconstructive surgery: a 10-year bibliometric analysis

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Background: Tissue expansion (TE) has attracted significant attention from researchers over the past decade. However, there are currently no bibliometric analyses in this field. We aimed to quantitatively and visually analyze the literature to explore the hotspots and frontiers in TE research.

Methods: We extracted all the documents on this topic published from the Web of Science Core Citation (WOSCC) database between 2012 and 2021. CiteSpace (version 5.8 R3) and VOSviewer (version 1.6.18) were used to perform the visualization analysis.

Results: A total of 1,085 documents were included in the analysis. The publication trend fluctuated over time. The United States led the research, and Harvard University was the most productive institution. *Plastic and Reconstructive Surgery* published the largest number of documents and had the most citations. Kim JYS was the most prolific and most cited author. The high-frequency keywords were "complications", "breast reconstruction", "outcomes", "tissue expander", "mastectomy", and "acellular dermal matrix" (ADM). "Surgical site infection", "tissue expander/implant", "bilateral prophylactic mastectomy", and "activated controlled expansion" were the keywords with the strongest citation bursts until 2021.

Conclusions: This study provided a complete analysis of the research on TE. The effect of ADM on the complication rates after breast reconstruction is the current hotspot of TE research in surgery. Patient-activated controlled expansion might be a promising future research direction for TE.

Keywords: Bibliometric analysis; tissue expansion (TE); defect reconstruction; breast reconstruction

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Introduction

Tissue expansion (TE) was first described by Neumann for ear reconstruction in 1957 (1). This technique was subsequently extended to breast reconstruction by Radovan in the late 1970s (2) and was reported by Becker in 1987 (3). It has been widely applied in plastic and reconstructive surgery. TE can be subdivided into internal TE and external TE. Conventionally, internal TE is performed in two stages. In the first stage, a tissue expander is placed in the subcutaneous region close to the area requiring reconstruction. The volume of the expander increases as saline solution is regularly—usually once or twice a week—injected into it, leading to skin growth. In the second stage, the expander is removed and additional skin is used for reconstruction (4). External TE promotes wound closure by exerting continuous tension to the wound margins. It reduces the risk of infection and avoids delaying definitive reconstruction but only partly achieves the expansion that can be attained with internal TE (5).

Compared with other techniques such as skin graft or flap transplantation, internal TE provides well-vascularized tissue that is similar in both color and texture to the surrounding skin tissue. The reduction of donor-site morbidity can also be achieved (6). However, it also has some significant disadvantages, including the lengthy duration of TE, the need for multiple-staged operations, and temporary discomfort (7). Moreover, for patients with large defects, the amount of skin provided by internal TE is often insufficient because of the limited regenerative capacity of skin (8). Due to its effectiveness and simplicity, TE has garnered keen interest among researchers in terms of its indications, complications, and improvements over the past decades (9). A larger number of related manuscripts are published every year. At present, there are no comprehensive reports about the publication trends, influential journals and authors, or hots pots and frontiers in this field.

Bibliometrics is an interdisciplinary subject that applies mathematical and statistical methods to analyze scientific literature (10) and has attracted the attention of academic researchers in recent years. Many researchers have employed this method to study rheumatic system diseases (11), cardiovascular system diseases (12), nervous system diseases (10), and cancer (13). Compared to reviews or meta-analyses, bibliometrics offers researchers information about the contributions of countries, institutions, authors, and journals (14). Research hot spots and frontiers can also be revealed.

In this study, we retrieved and collected the reviews and articles related to the surgical application of internal TE from the Web of Science Core Collection (WOSCC) database. Then, a quantitative and visual analysis was conducted using CiteSpace and VOSviewer. This study aimed to provide an overview of this field and help relevant doctors and researchers develop new directions for future TE research.

Highlight box

Key findings

- A bibliometric analysis was performed on studies investigating tissue expansion over the past 10 years. Keywords related to breast reconstruction appeared most frequently. “Activated controlled expansion” was one of the burst keywords that lasted until 2021.

What is known and what is new?

- Tissue expansion is one of the most widely used reconstructive techniques and many studies have been performed in this field. To our knowledge, this study is the first bibliometric analysis of literature related to tissue expansion.

What is the implication, and what should change now?

- This study provides an overview of the influential authors, countries, institutions, and journals on tissue expansion, and reveals the main research directions and hot spots. Relevant researchers can investigate patient-activated controlled expansion as a future research direction.

Methods

Data source and search strategy

The WOSCC is a leading global citation database that includes the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Emerging Sources Citation Index (ESCI), among others. We performed a literature search using WOSCC, and the data were downloaded within 1 day (March 1, 2022). The search strategy was as follows: Topic (TS) = (“tissue expansion” OR “tissue expander*” OR “skin expansion” OR “skin expander*” OR expander* OR expansion*) AND Web of Science Categories = (Surgery) AND Web of Science Index = (Science Citation Index Expanded OR Social Sciences Citation Index) AND Language = English AND Document types = (Article and Review). The publication year was confined to the period from 2012 to 2021. To ensure relevance, H.G and C.Y independently screened the

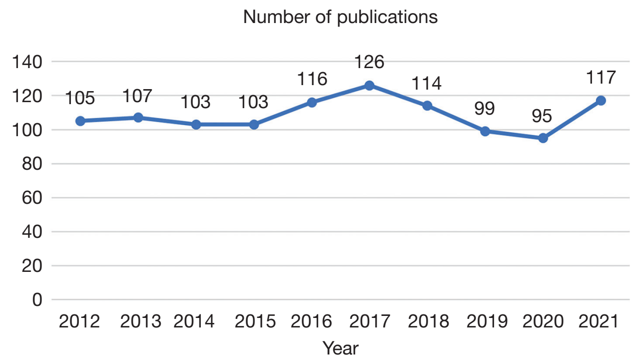

Figure 1 The publication trend for the 10 years between 2012 and 2021.

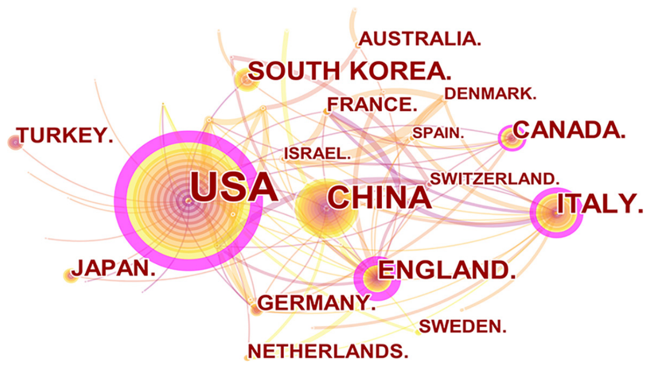

Figure 2 The network map showing the distribution of countries involved in TE research. TE, tissue expansion.

Table 1 The top 10 countries with the largest number of published articles

Rank	Country	Article, n	Centrality
1	USA	618	0.65
2	China	120	0.06
3	Italy	66	0.15
4	South Korea	45	0.00
5	England	43	0.29
6	Canada	23	0.12
7	Turkey	19	0.00
8	Japan	18	0.00
9	Germany	15	0.06
10	The Netherlands	8	0.00

titles and abstracts of all documents. Eligible documents were clinical studies and reviews related to internal TE. Any disagreements between the authors were resolved by consulting DW.

Data processing and bibliometric analysis

All retrieved documents were exported and saved as plain text with full record and references. Data including countries, institutions, journals, authors, references, total citations, and keywords were included in our study. Microsoft Excel 2021 was used to format these data into tables and to draw a line graph. CiteSpace (version 5.8 R3) was used to draw network maps as well as for country analysis, institution analysis, and burst detection. There are several nodes and lines in these maps. The size of the nodes represents the number of documents, while the thickness of the line represents the closeness of cooperation between countries or institutions. The outer purple circle denotes the centrality >0.1. Generally, a node with a centrality >0.1 is referred to as a key point. A keyword co-occurrence visual analysis was performed using VOSviewer (version 1.6.18). In the corresponding network map, the size of the nodes is determined by the keyword occurrence frequency.

Results

Analysis of publication trends

In total, 1,085 documents on TE were included in our study. The number of publications showed a slight fluctuation. The year with the largest number of documents published was 2017 (n=126). Thereafter, the number of publications fell and reached a low of 95 in 2020 (*Figure 1*).

Analysis of countries and institution distribution

A total of 1,030 institutions from 45 countries were involved in TE research. As shown in *Table 1*, the United States was the most productive country with 618 articles, and China was the second most productive country with 120 articles, followed by Italy (n=66). The United States, Italy, England, and Canada were the 4 countries with a centrality greater than 0.1 (circled in purple in *Figure 2*).

The top 10 institutions with the largest number of documents are listed in *Table 2*. The visualization map of the major institutions is shown in *Figure 3*. Harvard University (n=50) was the leading institution. The second and third

Table 2 The top 10 most productive institutions

Rank	Institution	Country	Articles, n	Centrality
1	Harvard University	USA	50	0.07
2	Chinese Academy of Medical Sciences	China	36	0.03
3	Northwestern University	USA	32	0.03
4	Memorial Sloan-Kettering Cancer Center	USA	27	0.10
5	The University of Michigan	USA	24	0.07
6	Stanford University	USA	22	0.05
7	Mayo Clinic	USA	22	0.02
8	Sungkyunkwan University	South Korea	20	0.00
9	The University of California, San Francisco	USA	16	0.00
10	The University of Pennsylvania	USA	14	0.00

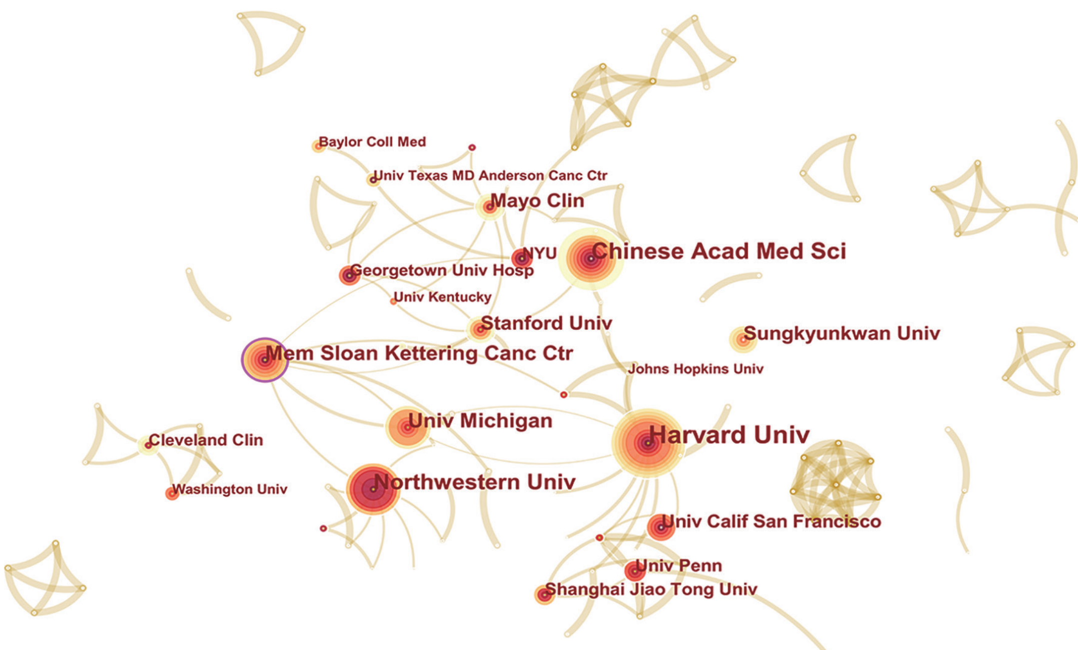

Figure 3 The network map showing the distribution of institutions involved in TE research. TE, tissue expansion.

institutions ranked by the number of documents were the Chinese Academy of Medical Sciences and Northwestern University, respectively. The top 3 institutions ranked by centrality were the Memorial Sloan-Kettering Cancer Center (0.10), Harvard University (0.07), and the University of Michigan (0.07).

Analysis of journals

The 1,085 articles were published in 81 journals. Of these, the top 10 journals published 839 (77.3%) (*Table 3*). *Plastic and Reconstructive Surgery* (n=243, 22.4%), *Annals of Plastic Surgery* (n=210, 19.4%), and *Journal of Plastic Reconstructive and Aesthetic Surgery* (n=121, 11.2%) published the highest

Table 3 The top 10 most productive journals in TE research

Rank	Journal	Articles, n	IF	Total citations, n
1	*Plastic and Reconstructive Surgery*	243	5.169	8,408
2	*Annals of Plastic Surgery*	210	1.763	2,600
3	*Journal of Plastic Reconstructive and Aesthetic Surgery*	121	3.022	1,652
4	*Journal of Craniofacial Surgery*	64	1.172	313
5	*Aesthetic Plastic Surgery*	57	2.708	622
6	*Annals of Surgical Oncology*	42	4.339	1,051
7	*Journal of Plastic Surgery and Hand Surgery*	29	1.295	464
8	*Gland Surgery*	28	2.160	328
9	*Aesthetic Surgery Journal*	25	4.485	292
10	*EJSO*	20	4.037	430

TE, tissue expansion; IF, impact factor.

Table 4 The top 10 most productive authors and most cited authors

Rank	Author	Articles, n	Citations, n
Most productive			
1	Kim JYS	31	1,039
2	Fine NA	23	582
3	Mum GH	23	333
4	Sbitany H	20	604
5	Pusic AL	18	706
6	Lee GK	18	198
7	Bang SI	17	105
8	Nahabedian MY	16	729
9	Xie F	15	147
10	Li QF	15	142
Most cited			
1	Kim JYS	31	1,039
2	Nahabedian MY	16	729
3	Pusic AL	18	706
4	Serletti JM	14	694
5	Fischer JP	13	673
6	Nelson JA	11	611
7	Sbitany H	20	604
8	Fine NA	23	582
9	Wilkins EG	13	551
10	Choi M	14	510

number of articles. These journals also ranked as the top 3 in terms of total citations. Notably, the *Annals of Surgical Oncology* had 1,051 total citations, which exceeded that of the *Journal of Craniofacial Surgery* and *Aesthetic Plastic Surgery*.

Analysis of authorship

A total of 4,157 authors contributed to TE research. *Table 4* presents the top 10 most productive authors and the top 10 most cited authors. Kim JYS had the most published articles in this field (n=31), followed by Fine NA (n=23), and Mum GH (n=23). He also ranked first in the analysis of cited authors. Although Nahabedian MY and Serletti JM published 16 and 14 articles, respectively they both had a high number of citations.

Analysis of cocitation and citation

There were 14,308 cited references included in this study. If 2 articles are cited simultaneously by a third one, then the relationship between the 2 articles is called co-citation. *Table 5* shows the top 10 most cocited references (15-24). Among these references, Chun *et al.* (15) ranked first, with 143 cocitations, followed by Albornoz *et al.* (16) and Breuing *et al.* (17), with 133 and 116 cocitations, respectively.

Analysis of keywords

The top 10 high-frequency keywords are listed in *Table 6*.

Table 5 The top 10 most cocited articles in TE research

No.	Title	Author	Journal	Cocitations, n	Year
1	Implant-based breast reconstruction using acellular dermal matrix and the risk of postoperative complications	Chun *et al.*	*Plastic and Reconstructive Surgery*	143	2010
2	A paradigm shift in US breast reconstruction: increasing implant rates	Albornoz *et al.*	*Plastic and Reconstructive Surgery*	133	2013
3	Immediate bilateral breast reconstruction with implants and inferolateral AlloDerm slings	Breuing *et al.*	*Annals of Plastic Surgery*	116	2005
4	Acellular dermis-assisted breast reconstruction	Spear *et al.*	*Aesthetic Plastic Surgery*	114	2008
5	Acellular human dermis implantation in 153 immediate two-stage tissue expander breast reconstructions: determining the incidence and significant predictors of complications	Antony *et al.*	*Plastic and Reconstructive Surgery*	102	2010
6	Predicting complications following expander/implant breast reconstruction: An outcomes analysis based on preoperative clinical risk	McCarthy *et al.*	*Plastic and Reconstructive Surgery*	99	2008
7	Nonexpansive immediate breast reconstruction using human acellular tissue matrix graft (AlloDerm)	Salzberg *et al.*	*Annals of Plastic Surgery*	98	2006
8	A single surgeon's 12-year experience with tissue expander/implant breast reconstruction: Part I: A prospective analysis of early complications	Cordeiro *et al.*	*Plastic and Reconstructive Surgery*	94	2006
9	A meta-analysis of human acellular dermis and submuscular tissue expander breast reconstruction	Kim *et al.*	*Plastic and Reconstructive Surgery*	92	2012
10	The effect of acellular dermal matrix use on complication rates in tissue expander/implant breast reconstruction	Lanier *et al.*	*Annals of Plastic Surgery*	90	2010

TE, tissue expansion.

Table 6 The top 10 high-frequency keywords

No.	Keywords	Frequency
1	Complications	348
2	Breast reconstruction	323
3	Outcomes	227
4	Tissue expander	225
5	Mastectomy	185
6	Acellular dermal matrix	168
7	Tissue expansion	151
8	Reconstruction	147
9	Surgery	138
10	Cancer	114

Among them, "tissue expander" and "tissue expansion" were expected because they were the search terms. Apart from these 2 keywords, keywords with a frequency >150 were "complications" (n=348), "breast reconstruction" (n=323), "outcomes" (n=227), "mastectomy" (n=185), "acellular dermal matrix" (n=168), and "tissue expansion" (n=151).

As shown in *Figure 4*, these keywords were classified into 5 different clusters, represented by 5 colors. The blue cluster comprised the keywords related to complications, implant, TE, and risk factors, while the yellow cluster was mainly related to acellular dermal matrix, Alloderm, coverage, etc. The keywords of the green cluster were related to reconstruction, defects, repair, head, neck, face, etc. The keywords of red cluster were largely associated with outcomes, cancer, skin-sparing mastectomy, nipple-sparing mastectomy, radiotherapy, and patient satisfaction. In addition, the purple cluster was the smallest cluster and covered keywords related to prepectoral breast reconstruction.

The top 25 keywords with the strongest citation bursts are shown in *Figure 5*. "Capsule formation" had the strongest burst (4.55), which emerged in 2012 and ended in 2014. "Surgical site infection", "tissue expander/implant", "bilateral prophylactic mastectomy", and "activated controlled

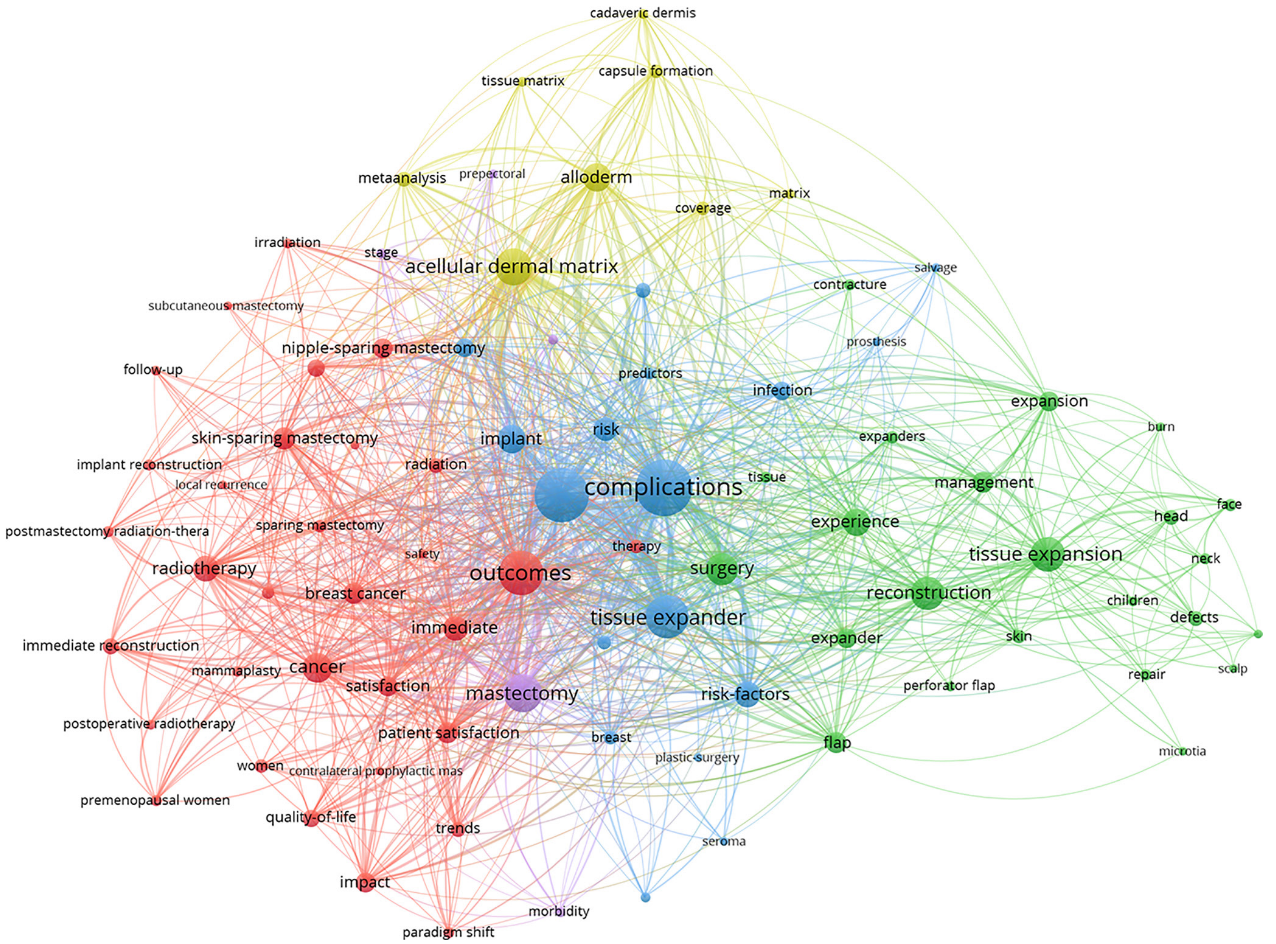

Figure 4 Keyword co-occurrence knowledge map.

expansion" were the burst keywords that lasted until 2021.

Discussion

General information

In this study, we combined bibliometrics with visualization to analyze data from 1,085 articles published for the period of 2012–2021. The publication trend fluctuated slightly, which may be attributed to the different research directions across countries or institutions. The number of documents reflects the scientific research levels of a country or institution (25). The analysis of countries' distribution indicated that the United States took the lead in TE research. Nearly all productive institutions came from this country. Furthermore, Italy, England, and Canada had a centrality greater than 0.1, which indicated that they made considerable contributions to TE research. Although China was ranked second (*Table 1*), its centrality was 0.06, suggesting the absence of collaboration with other countries.

The analysis of journals can help identify the zone of core journals. *Plastic and Reconstructive Surgery*, *Annals of Plastic Surgery*, and *Journal of Plastic Reconstructive and Aesthetic Surgery* were the top 3 journals in terms of the number of documents and citations. Thus, numerous relevant studies could be found in these journals. *Annals of Surgical Oncology* also deserves the attention of researchers because of its high number of citations. Based on the number of published articles and total citations, Kim JYS can be considered a particularly influential author in this field.

Through reference cocitation analysis, researchers can gain a better understanding of the basis of subject research (26). "Implant-based breast reconstruction using acellular dermal matrix and the risk of postoperative

Figure 5 The top 25 keywords with the strongest citation bursts from 2012 to 2021. The blue bar represents the time interval, and the red bar represents the duration of the keyword burst.

complications" was the most co-cited reference. The author found that postoperative seroma and infection were related to the introduction of ADM (15). "A paradigm shift in US breast reconstruction: increasing implant rates" ranked second. This study reported that the growth in implant use might popularize immediate breast reconstruction (16). The third most cocited article was "Immediate bilateral breast reconstruction with implants and inferolateral AlloDerm slings", which was published in 2005 by Breuing *et al.* (17). This study was the first to introduce the AlloDerm slings technique. These documents laid the foundation for TE research.

Research directions, hotspots, and frontiers

Analyzing keywords in documents can reveal research directions, hotspots, and frontiers in a particular research area. Although we divided the keywords into 5 clusters (*Figure 4*), the main research directions of TE can be summarized as nonbreast applications and breast reconstruction. According to the keyword co-occurrence analysis, the effect of ADM on the complication rates after breast reconstruction is the current hotspot. The keywords burst analysis indicated that patient-activated controlled expansion might be a future research direction for TE.

TE has been a well-established technique for soft tissue reconstruction. As presented in *Figure 4*, its nonbreast applications mainly include ear reconstruction, scalp reconstruction, facial defect reconstruction, and soft tissue defect reconstruction in other regions of the body. For ear reconstruction, TE provides an expanded skin flap to cover the framework and is usually accomplished in

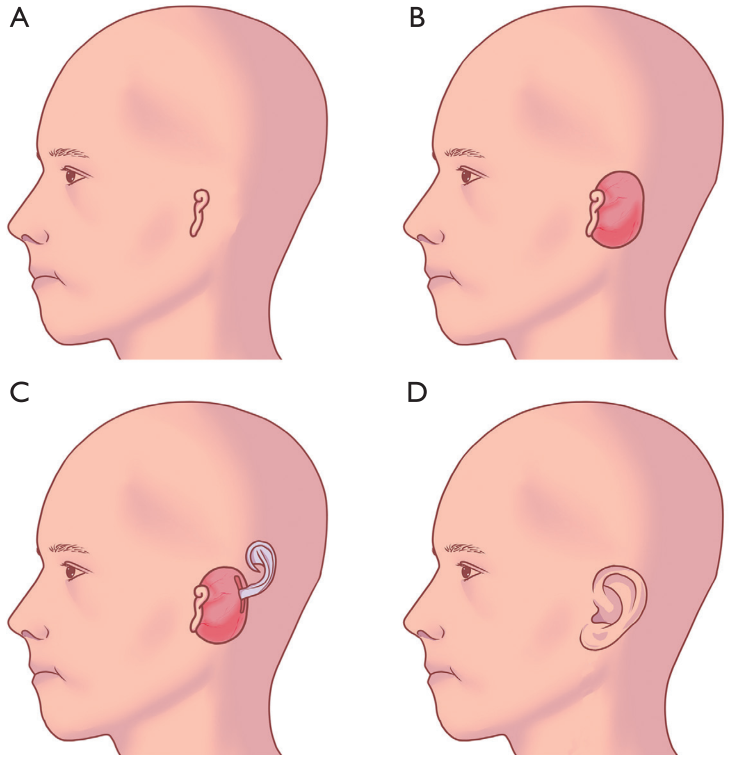

Figure 6 The process of ear reconstruction. (A) Preoperative view. (B) The tissue expander is inserted into the retroauricular area and the TE process begins. (C) The cartilage framework is covered by expanded skin. (D) Postoperative view after tragus and concha construction. TE, tissue expansion.

3 stages (27,28). In the first stage, a tissue expander is placed subcutaneously in the retroauricular area. The second-stage surgery involves ear reconstruction using an autologous costal cartilage upon completion of TE (29). Tragus and concha construction is performed in the third stage (*Figure 6*).

A hairless scalp can result in a severe psychological burden on patients, and TE is a good choice for hair restoration (30). The subgaleal and subcutaneous planes are the 2 recommended planes for tissue expander implantation (31). After full expansion, the expanded flap is used to repair the defects (*Figure 7*).

Facial defects secondary to trauma, burn, and tumor resection can lead to both physical and functional difficulties. TE offers an excellent color and texture match for the reconstruction of defects. One of the most frequently adapted flaps is the expanded forehead flap (32,33). The first-stage surgery involves the expander insertion, and the second-stage surgery involves the expander removal and forehead flap transfer. The distal portion of the flap is used to reconstruct facial defects, and the pedicle is cut off in the third stage (*Figure 8*). The trunk and limbs are also potential body parts for tissue expander insertion (34,35).

According to the 2020 cancer statistics, breast cancer is the most commonly diagnosed cancer in females worldwide, accounting for about 11.7% of all new cancer cases (36). At present, surgical resection is one of the main treatment strategies. For women undergoing partial or total mastectomy, breast reconstruction is a good method to improve their aesthetic outcomes, satisfaction, and quality of life (37). There have been many innovations and different-sized tissue expanders developed in breast reconstruction over the past few decades. Radovan introduced the first modern tissue expander consisting of a balloon and a port in 1976 (38), and Austed introduced the self-inflating tissue expander in 1977 (39). Then, in 1982, Radovan presented his experience of using the temporary tissue expander for breast reconstruction (2). McGhan Medical (Allergan) produced a tissue expander in different sizes, which allowed for the preferential expansion of the lower pole of the

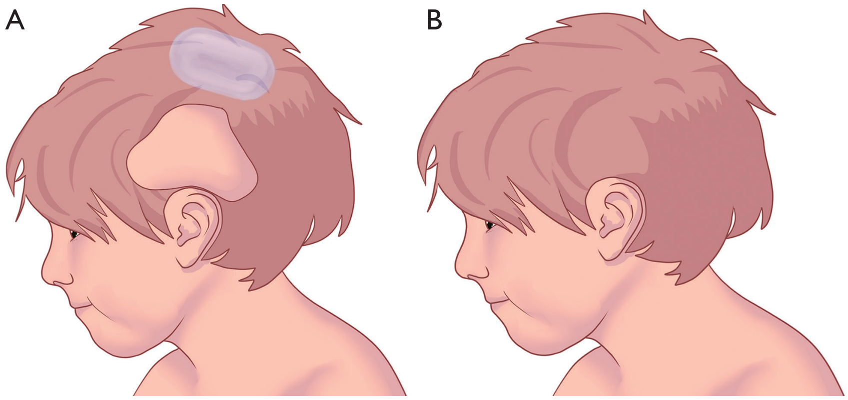

Figure 7 The process of scalp reconstruction. (A) The tissue expander is inserted into subcutaneous plane near the defect. (B) View after the expanded is used to repair the defect.

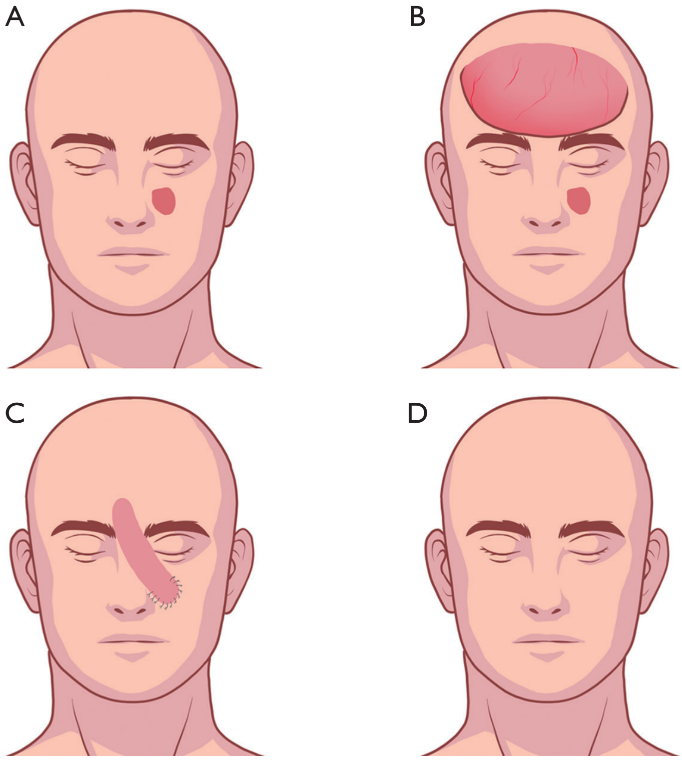

Figure 8 The process of facial defect reconstruction. (A) Preoperative view. (B) The forehead flap is expanded. (C) The distal portion of the flap is used to repair the facial defect. (D) Postoperative view.

breast to reconstruct a natural-looking breast (40,41). The application of ADM for the breast was first introduced in 2005 (17), and 2 years later, Widgerow developed a tissue expander with an external infusion pump controlled by patients (42). However, the pump increased the risk of infection.

In 2011, the results of a feasibility study of the Aeroform system, known as patient-activated controlled expansion, were reported (43) (*Figure 9*). The tissue expander/implant-based breast reconstruction can be classified based on the

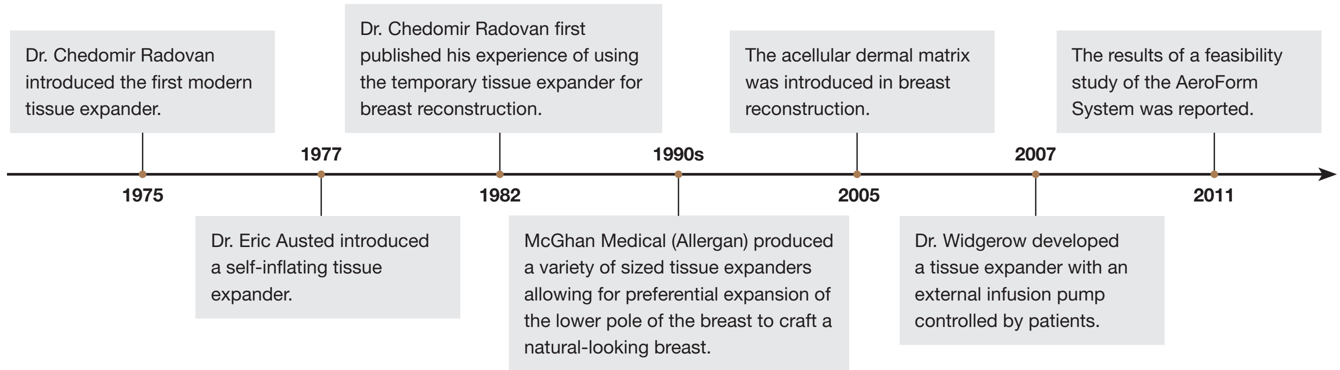

Figure 9 The timeline shows the innovations in tissue expansion and different tissue expanders.

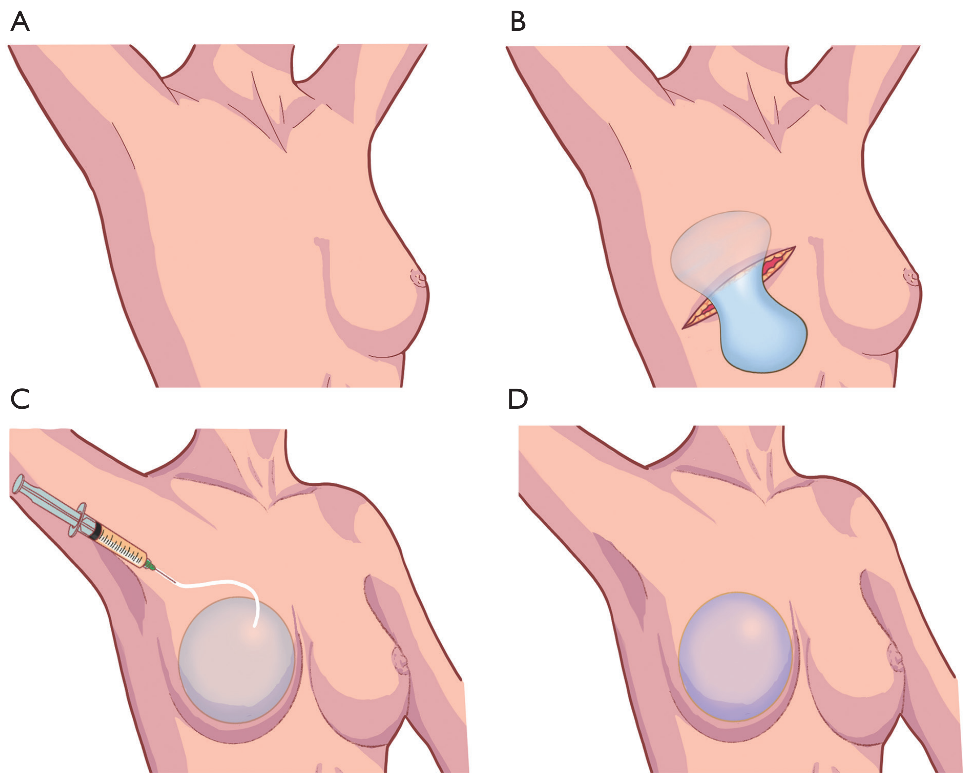

Figure 10 The process of breast reconstruction. (A) View after mastectomy. (B) A tissue expander is placed above or below the pectoralis major muscle in the first stage. (C) The process of TE. (D) The tissue expander is replaced with the implant in the second stage. TE, tissue expansion.

location of the implant into either dual-plane subpectoral breast reconstruction or prepectoral breast reconstruction. In the first stage, a tissue expander is placed above or below the pectoralis major muscle, which is replaced with an implant in the second stage (*Figure 10*) (44). Subpectoral breast reconstruction is the current standard procedure for tissue expander/implant-based breast reconstruction. This procedure requires a sufficient amount of skin and muscle to cover the tissue expander. However, the elevation of the pectoralis may cause animation deformities, muscle spasms, chest tightness, and pain (45). As a less invasive procedure, prepectoral breast reconstruction has become popular in recent years. Its advantages include the elimination of animation deformities and muscle spasms. Studies have also shown that it is associated with less pain, is time-saving, and provides excellent aesthetic outcomes (46-48). Candidates for prepectoral breast reconstruction should have well-vascularized skin flaps and sufficient fat depots for fat grafting based on the concept of a bioengineered breast (49).

Due to the lack of lower pole coverage of the implant, subpectoral breast reconstruction involves a risk of implant migration and exposure. The introduction of ADM provides a solution to these problems. It also improves aesthetic results, especially in the inframammary fold position and the inferior breast contours (50). Despite the aforementioned advantages, the increase in complication rates is of concern. A meta-analysis performed by Kim *et al.* demonstrated that ADM-assisted tissue expander breast reconstruction had a higher incidence of postoperative complications. The total complication rate was higher in patients with ADM (15.4%) than in those without ADM (14%), and ADM doubled the risk of infection (23). Smith *et al.* found that the use of ADM was significantly associated with postoperative complications (51). Dikmans *et al.* likewise observed increased complication rates of wound infection, wound dehiscence exposure, and skin necrosis in patient reconstructions with ADM (52). A similar result was reported in a recent multicenter randomized controlled trial (RCT) (53). Although the complication rate in patients who received immediate implant-based breast reconstruction with ADM showed no statistical difference compared to that in patients without ADM, the total number of complications was higher in the ADM group. Overall, the use of ADM appears to increase complications in breast reconstruction. These advantages and disadvantages must be weighed judiciously for patients undergoing ADM-assisted reconstruction so that reconstructive surgeons can make an optimal choice. Further, more RCTs should be conducted to obtain high-level clinical evidence.

Traditional breast TE requires the use of a saline-based tissue expander. A serial percutaneous injection is administered weekly or biweekly by surgeons in the clinic, which is uncomfortable and time-consuming, and may hinder patients from undergoing breast reconstruction (54). The AeroForm System consists of an implantable tissue expander containing a compressed carbon dioxide reservoir and a handheld control device. Patients can manually release a predetermined volume of carbon dioxide gas using the controller under the direction of surgeons. This patient-activated controlled expansion eliminates the need for saline injections and can be performed in any location. In 2011, Connell reported the results of a clinical study on the AeroForm System (43); this was a proof-of-concept study and required further investigation. Three Australian clinical trials, including Patient Activated Controlled Expansion I (PACE I), Patient Activated Controlled Expansion II (PACE II) and Study of AeroForm Tissue Expander for Breast Reconstruction (ASPIRE), indicated that the AeroForm System is time saving, needle free, safe, and effective (43,54-56). Data from the Patient Controlled Tissue Expansion for Breast Reconstruction (XPAND) study revealed significantly shorter expansion and overall reconstructive times (57). These were also confirmed in the subsequent XPAND II study (58). However, the available literature remains inconclusive, and thus, additional clinical trials are required to provide an evidence base for clinical decision-making.

To our knowledge, this is the first bibliometric analysis of TE in clinical surgery. However, there were some limitations in our study that should be noted. First, this study is based on the WOSCC database. Some high-impact articles might have been excluded because they were not included in this database. Second, due to the limitation of the search terms, a few relevant articles were inevitably missed. Finally, we only limited the literature type to articles and reviews. Influential studies published in the form of letters, meeting abstracts, and proceeding papers might have been overlooked.

Conclusions

In this study, we used the bibliometric method to analyze 1,085 documents published on TE from 2012 to 2021. Despite its various indications, TE was mainly applied for breast reconstruction over the past 10 years. The effect of ADM on complication rates after breast reconstruction is the current hotspot of TE in surgery. Patient-activated controlled expansion might be a future direction for TE research.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3643/coif). The authors have no conflicts of interest to declare.

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