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Global research trends in endoscopy applications in submucosal tumor: A bibliometric analysis of studies published from 2010-2024

Lin KX *et al.* Bibliometrics of ER in SMTs

Abstract

BACKGROUND

Submucosal tumors (SMTs) are rare conditions frequently encountered in clinical endoscopic practice. With advancements in endoscopic technology over the past decade, endoscopic management of SMTs has emerged as a significant research area.

AIM

To examine developments in this field, compare contributions from different countries, institutions, and authors, and identify potential research hotspots.

METHODS

Relevant publications on the endoscopic management of SMTs between January 2010 and June 2024 were extracted from the Web of Science Core Collection database. Microsoft Excel, VOSviewer, and CiteSpace were used to analyze publication trends and visualize key results.

RESULTS

Overall, 339 publications by 1840 authors from 31 countries/regions were included. *Surgical Endoscopy and Other Interventional Techniques* was the most prominent journal in the field (62 articles, 18.29%). Most research was conducted in China ($n = 212$), followed by Japan ($n = 47$), and the United States ($n = 28$). Fudan University (China) was the most active institution, and Professor Zhou published the most papers ($n = 27$) with had the highest citation count ($n = 1167$). Emerging research topics include full-thickness resection devices , defect closure, and cooperative surgery.

CONCLUSION

The endoscopic management of SMTs has advanced rapidly over the past 14 years. However, national and regional development disparities persist, with limited high-level studies and weak inter-institutional and international collaboration. Device-assisted

techniques and combined surgical endoscopic resections are emerging as key areas for future research.

Key Words: Submucosal tumors; Endoscopic resection; Bibliometrics; Publications; Global

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Core Tip: With the advancement of endoscopic technology over the past decade, the endoscopic management of submucosal tumors has gradually become a significant research domain. Our study utilized bibliometric analysis to describe the development, compare the contributions from different countries, institutions, and authors, and analyze the potential hotspots in this field. We found that research in this field has progressed rapidly from 2010-2024. However, the imbalanced development between regions and the lack of high-level studies shouldn't be neglected. It is foreseeable that future innovation should prioritize device-assisted resection technologies and combined endoscopic-surgical strategies, with particular emphasis on establishing global cooperative networks.

INTRODUCTION

Submucosal tumors (SMTs), also known as subepithelial tumors, are protruding growths enveloped by an intact mucosal layer[1]. These tumors are relatively rare; however, their absolute number should not be underestimated. In China alone, 20000-30000 new SMT cases are reported annually. Moreover, the detection rate of SMTs has increased with the extensive use of upper gastrointestinal endoscopy[2,3]. A recent study found that approximately 1 in every 300 routine endoscopic examinations detect

an SMT[4]. This trend highlights the growing significance of SMTs in gastrointestinal diseases and the need for increased attention from clinicians and researchers.

The occurrence of SMTs varies across the gastrointestinal tract, with the stomach being the most common site (0.1%-0.6%), followed by the esophagus, duodenum, and colon[5-7]. SMTs encompass various lesions, including gastrointestinal stromal tumors, leiomyomas, lipomas, schwannomas, and carcinoids, each with distinct features. While SMTs smaller than 2 cm typically remain asymptomatic larger tumors can cause severe complications, including gastrointestinal bleeding, obstruction, and metastasis. Therefore, early and complete resection is recommended. Laparoscopic surgery has been the preferred treatment for SMTs; however, its invasiveness and higher surgical risks pose significant challenges, particularly for elderly or frail patients. Thus, developing less invasive and lower-risk therapeutic strategies is crucial.

The advent of endoscopic dissection has brought new hope. Since the first report of endoscopic resection (ER) of SMTs in 1994[8], significant advancements have been made in endoscopic diagnosis and treatment. Traditional endoscopic submucosal dissection (ESD) has evolved to ⁶ techniques such as endoscopic submucosal excavation, endoscopic full-thickness resection (EFTR), and submucosal tunneling ER (STER), which are particularly useful for esophageal and gastric SMTs[9,10]. Additionally, advanced suturing methods, notably the “purse-string” technique and over-the-scope-clip, have facilitated the ER of larger SMTs by improving wound closure and reducing complications[11]. Currently, endoscopic SMT management remains a critical area in the field, thus complementing the endoscopic treatment of mucosal diseases[12].

Bibliometrics, an emerging interdisciplinary field, integrates quantitative and qualitative analyses of scholarly publications to assess research impact within specific areas[13,14]. This approach enables comparative assessment of contributions from various countries, regions, institutions, journals, and authors while highlighting the historical development and future trajectory of a field. Additionally, bibliometric analyses help predict research trends and focal points[15]. The growing significance of bibliometrics is evident in its role in shaping government policies, informing clinical

guidelines, and forecasting research directions[16]. By employing a bibliometric method, this study provides the first global analysis of the literature on ER of SMTs. By examining the development of these techniques, the study presents a comprehensive overview that enhances acceptance and acts as a reference for endoscopic practitioners and medical policymakers. Additionally, the study identifies trends and research hotspots to help researchers pinpoint novel topics and formulate future research directions.

MATERIALS AND METHODS

Database

The data source for this study was the Science Citation Index Expanded within Clarivate's (Philadelphia, PA, United States) Web of Science Core Collection (WoSCC). Recognized as a key database for bibliometric analysis, WoSCC includes publications that meet stringent evaluation criteria[17]. Science Citation Index Expanded is a sub-database of WoSCC that focuses on natural sciences, indexing over 8600 authoritative journals across 176 subject categories.

Search strategy and screening criteria

All searches were completed on July 5, 2024. The search strategy was as follows: (TS = ("submucosal cancer") OR TS = ("submucosal carcinoma") OR TS = ("submucosal tumor") OR TS = ("SMT") OR TS = ("submucosal tumors") OR TS = ("SMTs") OR TS = ("subepithelial lesion") OR TS = ("subepithelial lesions") OR TS = ("SEL") OR TS = ("SELS")) AND (TS = ("endoscopic resection") OR TS = ("ER") OR TS = ("Endoscopic full-thickness resection") OR TS = ("EFTR") OR TS = ("EFR") OR TS = ("submucosal tunnel endoscopic resection") OR TS = ("STER") OR TS = ("Endoscopic submucosal dissection") OR TS = ("ESD") OR TS = ("Endoscopic submucosal excavation") OR TS = ("ESE") OR TS = ("Endoscopic Mucosal Resection") OR TS = ("EMR"))

After the initial search, two authors (Lin KX and Hu H) independently reviewed and screened the retrieved publications based on the following inclusion criteria: (1) The

article was published between January 1, 2010, and July 5, 2024; (2) Book chapters, preprints, news articles, errata, non-English publications, and irrelevant studies were excluded; (3) The publication language was English; and (4) The study focused on both SMTs and ER. Disagreements were resolved through discussion and consensus. Overall, 339 articles met the inclusion criteria and were included in the final analysis. Detailed procedures for screening and enrollment are illustrated in Figure 1.

Data collection

The titles, keywords, publication dates, countries and regions, institutions, authors, publishing journals, and citation counts were extracted from all eligible publications. The country, region, and institution of origin were determined based on the affiliations of the contributing authors. For example, if an article included authors from multiple institutions or countries/regions, it was counted for each contributing institution and country/region.

Bibliometric analysis

The collected data were imported into Microsoft Excel 2019 (Redmond, WA, United States), VOSviewer (version 6.1. R1 Basic, Leiden, Netherlands), and CiteSpace (version 6.1. R1 Basic) for quantitative and qualitative analyses. VOSviewer is particularly useful for co-occurrence and co-citation analyses[18]. CiteSpace, a Java-based application, facilitates cluster analysis, timeline visualization, and citation burst detection[19]. Combining these two software packages enables comprehensive depiction of the evolution, structure, and interconnections within the knowledge domains through visual analyses of scholarly literature[20]. VOSviewer was used to map and visualize the network of countries/regions, institutions, authors, and keywords through co-occurrence analysis. In the network visualization, the size of each dot represents the number of publications by an author, institution, or country, whereas the lines connecting the dots indicate the strength of the co-occurrence among them. In the overlay visualization, clusters are color-coded based on the time course, with the

average appearing year (AAY) - the average mean publication year of articles containing particular keywords - used to evaluate the novelty of research topics.

² The options used in CiteSpace included a time slice set to “2010-2024,” with 1 year per slice, and the selection criteria set to “g-index”. The scale factor k was set to “10”, and “Pathfinder” and “Pruning Networks” were applied to optimize the structure while reducing redundant links. Keywords were used to label clusters, with cluster labels generated through a latent semantic indexing algorithm. The contributions of countries/regions, institutions, and authors to global publications were assessed by ranking the number of publications, citations, and average citations per publication. ¹ Price’s law is extensively employed in bibliometric analysis and posits that the square root of the total number of writers in a given field accounts for 50% of the publications on a given topic^[21]. GraphPad Prism 10 and Adobe Illustrator 2020 were used for graphical presentation.

RESULTS

Publications on endoscopy application in SMTs from 2010 to 2024

Overall 339 published papers were identified in the WoSCC search, comprising 252 original articles, 53 case reports, and 34 reviews (Figure 1). Figure 2 illustrates the trend in the total number of publications and their composition from 2010 to 2024. The bar chart displays the proportion of original articles, case reports, and reviews published each year, whereas the line graph represents the annual trend for each publication type (Figure 2). Specifically, all three types of literature showed an overall upward trend. The number of original articles peaked at 29 in 2022. Since 2011, the number of reviews has followed a slow but fluctuating upward trajectory, which reflects increasing efforts to summarize and consolidate knowledge on SMTs. Additionally, as reviews contribute to establishing industry consensus, their growth reflects increasing interest in the field. In 2024, the total number of publications was 17. Based on the current trajectory, publication activity is expected to grow, indicating sustained research interest and significant attention in this field. Furthermore, we compared the number of publications

related to specific sections of the digestive tract and analyzed their developmental trends (Supplementary Figure 1). Research on the gastrointestinal tract and rectum has expanded rapidly, with the number of publications ranked as follows: Stomach, esophagus, duodenum, and rectum. Conversely, the small intestine and colon areas have been relatively infrequent. This pattern reflects the current state of research on SMTs.

Distribution of journals

A total of 339 articles were published in 97 journals. Table 1 presents the 11 journals with the highest publication counts, with each containing at least 7 articles. Overall, these journals published 186 articles, accounting for over half of the total (54.87 %). This finding highlights their leading role in SMT-related topics. Notably, *Surgical Endoscopy and Other Interventional Techniques* had the highest number of publications in this field (62, 18.29%), followed by the *World Journal of Gastroenterology* (29, 8.55%) and *Digestive Endoscopy* (20, 5.90%). Of these 11 journals, 81.82% were classified as Journal Citation Indicator Q1 or Q2, indicating a relatively high academic standard in this field. However, fewer than half of the published articles appeared in high-impact journals (IF > 5), thus indicating the need for higher-quality research.

Distribution of countries/regions

A total of 31 countries/regions published relevant articles between 2010 and 2024. As shown in Figure 3A, the countries with more than 20 publications were China, Japan, the United States, and South Korea. Supplementary Table 1 lists the top 10 countries and their publications. Five European countries, four Asian countries, and one North American country (the United States) have published at least four papers. East Asia, Europe, and the United States are major contributors to research in this field. Figure 3B illustrates the annual publication variation in each country, with China publishing at least one article per year and showing an increasing trend over the years. This indicates that China has made rapid progress and has strong research capabilities in SMTs, which

hold a leading position globally. Japan, South Korea, and the United States follow closely in this regard. Figure 3C displays the average publication year by country, and the timeline indicated by different colors shows the sequence of time. The countries that started focusing on this field earlier were Germany, Japan, the United Kingdom, and South Korea, whereas China, the United States, Poland, and Italy were relatively new to the field. When evaluating collaborations between countries (Figure 3C, Supplementary Figure 2), it can be found that the connection between Asia and the United States is tighter than that between Asian and European countries and that European countries have closer internal cooperation but fewer connections with Asian countries and the United States. Centrality is used to assess the status of the nodes (keyword, country, institution, or author) in a network. High centrality often has higher citation frequencies and disciplinary influence and can reflect research hotspots and frontiers in the field[22]. Figure 3D shows that Germany has a higher centrality (0.47), thus indicating its contribution to more influential articles in this field. China (0.37), the United States (0.34), and France (0.13) follow closely. Other countries had lower centralities. This suggests that these countries must focus on increasing publication volume and enhancing research quality to strengthen their global influence.

Distribution of institutions

The 12 institutions with the highest number of publications are listed in Supplementary Table 1. Fudan University published the most publications, accounting for 11.21% of all the publications. Other centers with a significant number of publications include Central South University and China Medical University, *etc.* Among the top 12 institutions, Harvard Medical School ranks 8th and Pusan National University ranks the 12th. The institution with the highest average number of citations was Fudan University, with a total citation count of 1348, significantly exceeding the 2nd institution (Central South University) which has 280 citations. Fudan University also possessed a higher centrality (0.04). These results suggest that Fudan University is at the forefront of SMT research, and its influential work is widely recognized and cited by peers.

A cluster analysis of all institutions identified two primary clusters (Figure 4A): Cluster 1, focusing on “Endoscopic Total Resection”, and Cluster 2, centered on “Endoscopic Tunneling Technique”. Cluster 1 has a slight prevalence and emerged more recently. Within this cluster, Fudan University is the most contributive institution, whereas, in Cluster 2, China Medical University, Central South University, and the General Hospital of the Chinese People’s Liberation Army hold leading positions. This distinction highlights the specialized focus and research strengths of these institutions. Figure 4A also indicates strong domestic collaboration but weaker international ties, a trend mirrored in the network graph (Figure 4B). Overall, institutional collaboration remains relatively low, particularly across countries. Regarding research chronology (Figure 4B), Shandong University and Qingdao University were early contributors, whereas Tongji University, the General Hospital of the People’s Liberation Army, and Qingdao University were more recent entrants. Among the earliest institutions (Supplementary Figure 3), Fudan University has demonstrated sustained research activity since 2011 by reflecting its continuous contributions to the field.

Distribution of authors and analysis of the most cited studies

Over the past 14 years, approximately 1840 authors have published in this field. The top 10 authors by publication count are listed in Supplementary Table 3 and Supplementary Figure 4. As shown in Supplementary Figure 4A, Zhou PH, Yao LQ, and Xu MD are the leading contributors, with 27, 21, and 20 publications, respectively. They also have the highest citation frequencies, with 1167, 1083, and 1006 citations, respectively. Other highly cited authors include Zhong YS, Chen WF, Cai MY, and Li QL, all of whom are influential in the field. Notably, 8 of the top 10 highly cited authors are affiliated with Fudan University. High-quality papers tend to receive more citations and highly cited papers often reference other high-quality works[23]. Based on Price’s law, 40 authors with over five publications were identified as core authors. A co-citation visualization analysis revealed that authors within the same institution are more closely connected, whereas collaboration across institutions is less frequent (Supplementary Figure 4B)[21].

In the author overlay visualization (Supplementary Figure 4C), researchers from Shandong University, such as Jiao TT and Lu JY, were early contributors, while those from the General Hospital of the PLA, such as Chai NL and Du C, joined the field later. The author density visualization (Supplementary Figure 4D) highlights Zhou, Xu, and Yao with dark colors and large circles, thus indicating their prominence in the field. Supplementary Table 4 presents the 10 most-cited papers between 2010 and 2024, with citation counts ranging from 110 to 291. Notably, four were published in *Endoscopy*, two in *Gastrointestinal Endoscopy*, and two in *Surgical Endoscopy and Other Interventional Techniques*, while the remaining two appeared in *Cancer* and the *Journal of the American College of Surgeons*. The most highly cited research paper, *Endoscopic Full-Thickness Resection Without Laparoscopic Assistance for Gastric Submucosal Tumors Originating from the Muscularis Propria*, was authored by Zhou PH from Fudan University. Most of these focused on endoscopic techniques, with three investigating EFTR, three exploring STER, three examining ESD, and one addressing endoscopic management. Notably, five of the 10 highly cited articles originated from Fudan University, thereby highlighting its significant contributions to the field.

Distribution of hotpots and frontiers

We analyzed 859 keywords that occurred over five times using VOSviewer (Figure 5A). Standardized keywords provide valuable insights into the research field and are often more effective than titles in defining a study's subject. After merging synonyms and removing on-informative terms, 56 keywords were identified and categorized into five clusters (Figure 5A). Among the identified keywords, "management" appeared most frequently (91 occurrences) and was strongly connected with terms such as "gastrointestinal stromal" and "diagnosis".

In Cluster 1, the following keywords frequently appear: "diagnosis", "ESD", "ultrasound", and "fine-needle-aspiration". In Cluster 2, related keywords include "management", "complications", and "enucleation". In Cluster 3, the main keywords are "efficacy", "full-thickness resection", "feasibility", "GIST", and "outcomes". In

Cluster 4, several high-frequency keywords are “device”, “laparoscopic surgery”, and “cooperative surgery”. In Cluster 5, frequently appearing keywords are “endoloop”, “closure”, and “perforations”. A summary of the high-frequency terms indicates that these clusters represent five major research areas of SMTs: (1) Diagnosis and resection; (2) Complications and management; (3) Treatment evaluation; (4) Cooperative surgery; and (5) Wound closure. In Figure 5B, the clusters are colored according to the timeline. The AAY of keywords is used to assess topic novelty. Keywords such as “ultrasound” (Cluster 1, AAY: 2020.0), “cooperative surgery” (Cluster 2, AAY: 2019.11), “complications” (Cluster 3, AAY: 2020.0), “long-term outcomes” (Cluster 1, AAY: 2022.5), and “defect closure” (Cluster 4, AAY: 2019.5) are relatively recent. The blue keywords represent older topics, primarily found in Cluster 1. This finding suggests that new diagnostic technologies for SMTs, prognosis, complication management, and wound closure strategies are emerging research trends.

Additionally, CiteSpace was employed for keyword timeline and cluster analysis. As shown in Figure 5C, the keywords were divided into nine clusters, including “endoscopic resection”, “exposed endoscopic full-thickness resection” and “endoscopic submucosal dissection”. The timeline shows when the key terms appeared in each cluster. The figure highlights recently frequent keywords, including full-thickness resection device, ultrasound, over-the-scope-clip, and laparoscopic surgery, which reflect current research trends within each cluster. We used burst detection, a method for identifying a sudden emergence of new concepts over time, to analyze keyword trends over the past 14 years (Figure 5D). The keyword “esophagogastric junction” had the highest citation burst strength (4.66) over the past 14 years, thus indicating increased research interest in SMTs at this site. High-burst keywords emerging in the past 5 years include full-thickness resection device, defect closure, and cooperative surgery. These emerging keywords align with cluster results in Figure 5C and suggest a research shift toward new endoscopic devices and laparoscopic-surgical endoscopic cooperative procedures.

Total link strength (TLS) represents a keyword that appears in conjunction with other keywords and helps identify the central themes and degree of interaction among different research topics within the SMTs field. Keywords with higher TLS values are likely to be more integral to the discussion and may represent established research areas or emerging trends of interest in SMT research[24]. Supplementary Table 5 lists the top 10 keywords, showing that “management” had the highest TLS, which indicates that the existing studies place great importance on the management of SMTs after endoscopy. Other keywords include “diagnosis”, “endoscopic submucosal dissection”, and “full-thickness resection”, indicating that these related themes are closely interrelated and intertwined in SMT research. When sorted by centrality, the three keywords “diagnosis”, “endoscopic submucosal resection”, and “suturing” emerge as having the highest centrality, which neatly encapsulates the three domains of SMT research.

Analysis of co-cited reference cluster

A co-citation network can generate a cluster network diagram (Figure 6A) and a co-citation timeline view (Figure 6B) when various references are cited repeatedly. We categorized the cited literature into 10 primary labels. Each node in the network represents a cited article, and its size is based on the total citation frequency of the associated articles. These 10 main labels are: “predicting technical difficulties”, “differential diagnosis”, “Japanese multicenter”, “large tertiary hospital”, “defect closure”, “upper gastrointestinal submucosal tumor”, “muscularis propria layer”, “resorbable suture”, “submucosal tunneling endoscopic resection”, and “device-assisted endoscopic full-thickness resection” (Figure 6A). From the timeline of the labels (Figure 6B), it can be seen that from 2015 to the present, popular research labels have been predicting technical difficulties, multicenter studies, large tertiary hospital studies, STER, and device-assisted endoscopic full-thickness resection. This indicates that recent years have seen a focus on multicenter research, full-thickness resection techniques, and

the application of tunneling methods, reflecting current trends and interest in the scope of SMTs.

DISCUSSION

We analyzed nearly 14 years of research on the ER of SMTs. The study found that since 2013, ER of SMTs has gradually increased and maintained a stable volume of publications for 10 years, indicating sustained interest in this field. Statistics show that most publications are concentrated in endoscopy journals, such as *Surgical Endoscopy* and *Gastrointestinal Endoscopy*. Therefore, it is likely that future research will be published in these journals. Analyzing the number of publications by the location of SMTs, esophageal, gastric, and rectal research accounts for a significant percentage, whereas colonic and small intestinal studies are less common. The low number of publications on small intestinal SMTs may be owing to the difficulty in accessing the small intestine and the scarcity of accessories suitable for balloon-assisted enteroscopy. The lower incidence of colonic SMTs could be because malignant SMTs are less common on colon imaging, and findings of lipomas of the gastrointestinal tract are primarily benign lipomas, and follow-up is the primary approach[25]. Another aspect is that if closure after ER of colonic SMTs is unreliable, it greatly increases the chance of a second laparotomy. In the future, with the enrichment of accessories for small intestinal resection and the development of safe closure methods, research on the ER of SMTs in these two areas will continue to increase.

Looking at the geographical location of the journals (Figure 3A), both the East and West are concerned with this topic. However, in terms of the actual publication volume, East Asian countries are the leading countries. China, Japan, and South Korea ranked first, second, and third in terms of the total number of research publications, respectively. In terms of total citations, China had the highest number of citations; however, in terms of citations per article, Japan, despite having fewer publications, had a higher average. Germany, although having fewer publications, had a higher average centrality, indicating a higher quality of research. This study also highlights significant

disparities in regional research efforts. In 2018, the Zhongshan Hospital of Fudan University led the formation of China's first expert consensus on SMTs endoscopic management, which was updated in 2023[26]. In 2019, the American Society for Gastrointestinal Endoscopy released guidelines for EFTR and STER in 2019[27]. In Japan, EFTR will receive special medical approval from the Japanese Ministry of Health by 2020[28]. This reflects a geographic imbalance in development and acceptance, although the concept of endoscopic treatment for SMTs is gaining increasing attention. This underscores the need for enhanced global collaboration to address gaps in research and practice and ensure that advancements in one region can benefit patients and providers worldwide. This also suggests the potential for improvement in the international recognition and management of SMTs, with the possibility of more countries adopting and developing guidelines in the future.

In terms of institutions and scholars, the Zhongshan Hospital of Fudan University leads among all institutions, followed by Central South University and China Medical University. Techniques such as ESE[29] and STER[30] were first reported by this center, and expert consensus on related SMTs was written by this unit, highlighting the role of this center in the field. Among researchers, authors such as Zhou have not only published the most papers in this field but also have high-quality research. This publication record shows that they have become influential core teams in the field of ER of SMTs, conducted many studies, and laid a solid foundation for future development. Additionally, our analysis revealed that while collaboration within countries and institutions is strong, there is a scarcity of cooperation with institutions outside of one's own and with international peers, indicating a continued need for more multicenter research initiatives.

By analyzing keywords, endoscopic research on SMTs covered aspects such as diagnosis, treatment, management, risk factor analysis, and traditional surgical procedures. Recent research has focused on switching from aspiration and ligation to cooperative surgery, suturing, and other novel techniques. As endoscopic dissection and laparoscopic dissection each have their strengths and weaknesses, laparoscopic and

endoscopic cooperative surgery (LECS), which takes the essence of both sides, has received increased attention. A retrospective single-center study reported the successful preservation of residual gastric motility after LECS[31]. Additionally, an increasing number of updated indications have been reported owing to modified LECS procedures, such as inverted-LECS, non-exposed endoscopic wall-inversion surgery, and closed-LECS[32]. Although these novel LECS-derived techniques were not present at a sufficiently high frequency to be included in the clustering analyses based on the latest hotspots and wide applications of cooperative surgery, we believe that they could also become the focus of future research. Moreover, reliable suturing is the key to the endoscopic treatment of SMTs. Recent articles on closure clips[33-36], and our analysis (Figure 5C and D) suggest that endoscopic secure suturing may also become a focus of future research. For innovation in surgical procedures, no-touch EFTR, under the condition of ensuring the integrity of the tumor capsule, reduces the risk of tumor dissemination to the greatest extent[37-39]. This technology is expected to become popular in the future.

The publications on SMTs extracted from the WOS database were accessed. However, this study has some limitations. We only considered publications written in English; therefore, we may have underestimated the important research published in other languages. Additionally, more recent papers may not have accumulated a large number of citations at the time of this study, which may have affected quality assessment. Finally, each author of the article defined the country/region/institution of origin, which may have led to overvaluation when assessing effectiveness because of the large number of non-first-cited publications.

CONCLUSION

In this study, we used a bibliometric method to depict global trends in research on the ER of SMTs. East Asian countries have made the greatest contributions to the field of related research, while Western countries show a relative deficiency in the adoption and

research of ER of SMTs. New ER techniques and the combination of laparoscopy, as well as new suture techniques for large wounds, are the future development directions.

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