Review article

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Bibliometric analysis and visualization of research trends in total mesorectal excision in the past twenty years

Yun Pan, MD[a], Xianyu Deng, MD[b], Xin Chen, MD[c,*], Moubin Lin, MD, PhD[a,*]

Background: Rectal cancer leads a major disease burden worldwide. Total mesorectal excision (TME) is the standard treatment for locally advanced or node-positive rectal cancer, while attempts to improve the surgery such as laparoscopic and transanal TME are widely used but have their inherent limitations. This bibliometric study analyzed research trends, cooperation, and knowledge dissemination on TME over the past 20 years to inform future directions.

Methods: Relevant literature from 2003 to 2023 was extracted from the Web of Science Core Collection and analyzed with VOSviewer, CiteSpace, and R for publication patterns, countries, institutions, authors, and research hotspots.

Results: Five thousand three hundred forty-five related publications were included, with rising annual output and citations. The US and China contributed the most studies, while the Netherlands had greater influence. Leiden University ranked first in publications. The top authors were Heald, Kapiteijn, Sauer, Nagtegaal, and Peeters. Research shifted from cancer-focused to patient-centered care and from radiotherapy/chemotherapy to advanced surgery. Multicenter trials became more common.

Conclusion: Although the United States and China have the largest number of publications, it should be noted that the influence of these two countries in the field of TME research is not the highest, which does not match the number of publications. In addition, telemedicine, interdisciplinary, medical-industrial integration, etc. may be potential directions for future research in the field of TME.

Keywords: bibliometric, total mesorectal excision, visualization

Introduction

Rectal cancer is a significant global health concern and a major contributor to the overall burden of malignancies. According to the WHO 2020 statistics, colorectal cancer ranks fourth in terms of incidence and third in mortality among all cancers worldwide[1]. In 2020, there were an estimated 1.93 million new cases and 916 000 deaths from colorectal cancer, with rectal cancer accounting for a considerable proportion of these cases. The incidence and mortality rates of rectal cancer vary by geographic location, reflecting differences in risk factors, screening practices, and healthcare systems. Several risk factors have been identified for colorectal cancer and they may vary between colon and rectal cancers due to their different embryonic origins and functions. Given the location of the rectum within the pelvic cavity and its proximity to genitourinary organs, rectal tumors may present with unique clinical manifestations compared to other gastrointestinal cancers; the diagnosis and management of rectal tumors have increasingly been considered as separate entities from other parts of the colon[2,3].

Advances in surgical techniques have led to improved outcomes for patients with rectal cancer. Total mesorectal excision (TME), now the gold standard for treating locally advanced or node-positive rectal cancers, has been shown to dramatically reduce the local recurrence[4,5] and decrease the risk of genitourinary dysfunction by preserving autonomic nerves[6]. TME should be

HIGHLIGHTS

- Total mesorectal excision (TME) is the gold standard for treating locally advanced or node-positive rectal cancer.
- Laparoscopic TME and transanal TME are the two most widely used TME methods, but both have their limitations.
- A bibliometric analysis of TME literature from 2003 to 2023 reveals an increasing trend in the number of publications and citations.
- Researchers have shifted their focus from cancer itself to patient care and advanced surgical procedures, with a transition from single-center to multicenter studies.
- Telemedicine, interdisciplinary approaches, and medical-industrial integration may be potential directions for future TME research.

[a]Department of General Surgery, Yangpu Hospital Affiliated to Tongji University, [b]Department of Neurosurgery, Tenth People's Hospital of Tongji University, Tongji University School of Medicine, Shanghai and [c]Department of General Surgery, Affiliated Hospital of Nantong University, Nantong, Jiangsu, People's Republic of China

Yun Pan and Xianyu Deng contributed equally to the writing of this article.

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*Corresponding author. Address: Shanghai Yangpu District Central Hospital, People's Republic of China. Tel.:/fax: +86 137 613 601 08. E-mail: 1500142@tongji.edu.cn (M. Lin); Affiliated Hospital of Nantong University, Nantong, Jiangsu 226001, People's Republic of China. Tel.:/fax: +86 181 006 388 03. E-mail: dcchenxin@yeah.net (X. Chen).

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performed for all patients undergoing radical surgical resection of mid and low rectal cancers and results in a complete or near-complete mesorectal excision[7]. A standard TME can be performed transabdominally via either open, laparoscopic, or robotic approaches; currently, laparoscopic TME has become one of the general modalities to manage resectable rectal cancer[8]. Transabdominal TME can be associated with technical difficulties due to anatomic constraints, especially for distal rectal tumors in male patients with obesity who have a narrow pelvis[9]. In experienced centers, transanal TME (TaTME) has become popular and related with the potential to define the resection margins more clearly, indicating an acceptable intraoperative complication rate and similar therapeutic effects[4,10]; however, doubts on TaTME also arose since much more relevant urologic injuries, a higher possibility of carbon dioxide embolus, and more severe bowel dysfunction were found[11–13]. Other attempts to achieve a better quality of life and digestive and genitourinary functions among survivors, such as organ-preserving selective TME following short-course radiotherapy[14], a combination of preoperative chemoradiotherapy (CRT) and transanal endoscopic microsurgery[5], customized Denonvilliers' fascia excision[15], and local excision following CRT[16], are still in the process of research and exploration.

Although TME procedures have been improved in the development of medical technology, there is no research to analyze the research trend of TME in-depth, which limits the progress of TME research to a certain extent. So, to better understand the development of TME and related therapeutic strategies in rectal cancer, it is essential to clarify the paradigm shift in research. For this purpose, in this study, we have introduced bibliometric methods and techniques from library and information science. Visualized bibliometric analysis with mapping software tools creates a comprehensive approach for scholars from all disciplines, making it feasible to keep current with vast amounts of publications[17]. By employing these methods, we aim to map the literature landscape, identify key publications and trends, and analyze the patterns of collaboration and knowledge dissemination in the field of TME and relevant surgical treatments of rectal cancer. From the core information summarized and the most critical updates discovered in this bibliometric study, we can bring forth valuable insights into future trends of rectal cancer management both in scientific literature and clinical practice, ultimately enabling researchers and practitioners to gain a deeper comprehension of the present status of the field and discover opportunities for additional investigation and improvements.

Methods

Literature sources and search strategies

The literature of this study comes from the core collection of the Web of Science (WoS) database, and the last updated retrieval time is 15 May 2023. We used the retrieval strategy of TS = 'total mesorectal exci*', Citation Index = 'Science Citation Index Expanded (SCI-EXPANDED) –1975 to present' retrieval strategy, and a total of 7546 documents were retrieved. All the articles in the above documents were included, and the publication time of the documents was limited from 1 January 1 2003 to 15 May 2023, then a total of 5345 target documents were obtained (Fig. 1).

Visualization and statistical analyses

All complete articles meeting the inclusion and exclusion criteria together with citations are included in text format named 'download_TME'. Import the file into CiteSpace 6.2.R3 Advanced, VOSviewer 1.6.19, and R Package bibliometrix 4.1.2, and analyze the overall network structure, clustering, key nodes, and paths by extracting information such as title, author, author unit, country, or region[18]. CiteSpace combined with Microsoft 365 Excel is applied to data collection, collation, and visual analysis, including statistical and descriptive analysis: annual publications, citations; collaborative network analysis: mainly for authors; co-occurrence analysis: for keywords; citation bursts analysis: mainly for keywords; co-citation analysis: for authors and references. The VOSviewer (version 1.6.19) was used to explore the cooperation network between authors, institutions, and keywords. The R Package bibliometrix (version 4.1.2) was used to visualize parameters such as countries and regions, publications of institutions, and collaboration networks. GraphPad Prism 9 was used to fit linear models for annual publications and annual publication citations[19].

The specific parameters of the visual analysis are set as follows: the 'Top N% per slice' threshold for all calculations is set to 50. The time span is from 1 January 2003 to 15 March 2023, and the time slice of all analyzes performed with CiteSpace is set to '1 year per slice', and the cluster labels are extracted using the LLR algorithm. We follow the main steps of CiteSpace to visualize knowledge graphs, including time slicing, thresholding, modeling, merging, and mapping.

Charts interpretation

Both CiteSpace and VOSviewer display information such as institutions, authors, and keywords by generating nodes. Links represent the relationship between two nodes, the size of the nodes is determined by the co-occurrence frequency in the title and the abstract, and the colors of the nodes and links indicate different clusters or years[20,21]. CiteSpace can extract keywords and references from highly cited publications and build a dual-map overlay for journals. Therefore, CiteSpace can be used to explore research trends on topics[22].

Results

Annual growth trend of publications and citations

From 2003 to 2023, there were 5345 publications on the topic of TME in the WoS Core Collection. The 'WOS Citation Report' shows that the cumulative number of citations of these documents is 177 037, and the average number of citations per article is 33.12, showing an overall upward trend. Figure 2A shows the statistics of annual publications, and the number of publications in this field shows a three-stage trend. During the period from 2003 to 2015, the number of papers published each year showed a relatively stable growth trend, except that the number of papers published in 2007 was slightly higher than that of the previous and subsequent years (230). From 2015 to 2018, the number of annual publications decreased but remained stable at more than 310 annual publications. Since 2018, the number of annual publications has started to increase year by year again. By fitting the data, we observed a statistically significant relationship between year and number of publications (Fig. 2B). According to

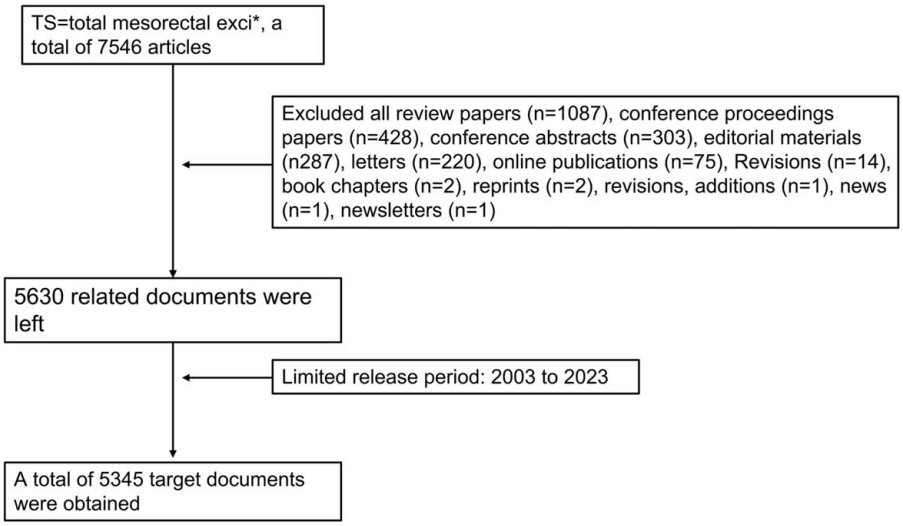

Figure 1. Flow chart of literature search and screening.

the fitting curve, the number of publications in 2023 is expected to be between 410.23 and 413.59, a slight decrease. The citation frequency of publications shows a trend of increasing year by year, and the frequency is expected to be between 20 163 and 21 028.6 articles in 2023 (Fig. 2B).

Country/region and institution analysis

According to our visualization (Fig. 3A), the five countries and regions with the largest number of publications are the United States (799 articles), Mainland China (750 articles), the Netherlands (479 articles), Japan (474 articles), and the UK (464 articles). From the perspective of the number of articles published by countries over time, the number of publications in China has the largest growth rate, surpassing that of Japan in 2014, Germany in 2017, the Netherlands in 2019, and the U.S. in 2020. Interestingly, the United Kingdom, as one of the top five countries by the number of published articles, has a lower growth rate than Germany in the number of publications (Fig. 3B). In addition, among the countries of the top 20 corresponding authors, the ratio of Multiple Countries Publications (MCP) to the country's total publications (MCP ratio) ranks the top five countries are Austria (17 articles, 35.8%), Australia (20 articles, 25.6%), the UK (87 articles, 23.6%), the Netherlands (93 articles, 23.1%), and Canada (22 articles, 19%). Although the United States has the most MCPs (107 articles), the MCP ratio does not rank in the top five due to the largest number of published articles. Although the total number of articles in China is second only to the United States, there are fewer articles published in cooperation with other countries (57 articles), so the MCP Ratio is also very low (Table 1). Among China's few international cooperations, cooperation with the United States is the closest (Fig. 3D).

The articles were authored by 4766 institutions, and 617 institutions published at least five articles. Among them, the top 20 institutions wrote a total of 2763 articles, accounting for 51.7% of all articles (Fig. 4A), and the institution with the largest number of publications was Leiden University in the Netherlands (300 articles, 5.6%). In addition, among the top 20 institutions in the number of publications, there are five Chinese universities, namely Sun Yat-sen University (282 articles, 5.3%), Kaohsiung Medical University (120 articles, 2.2%), Sichuan University (103 articles, 1.9%), Fudan University (97 articles, 1.8%) and Peking University (94 articles, 1.8%). As shown in Figure 4B, cooperation among agencies is more extensive than that between countries. Sun Yat-sen University works closely with many Chinese universities and research centers, as well as institutions in the UK, the US, and other countries. Leiden University and Catharina Hospital had the highest link strength, and collaboration between authors at these two institutions was stable and close (Fig. 4C).

Author analysis

In Figure 5A, VOSviewer software was used to create a visualization of the author's cooperation network, depicting the cooperation between authors in the field of TME, and the minimum number of papers per author was set to 10. Authors in a single cluster collaborate relatively closely, while there are relatively few connections between different clusters. From the timeline chart of the author's cooperation, the top three studies are TME (#0), transanal TME (#1), and preoperative chemotherapy (#2). At the same time, due to the high incidence of bowel cancer, basic research on bowel cancer has gradually increased in the past decade (#7), and robotic surgery (#9) and immunotherapy (#16) have also begun to receive attention around 2010 (Fig. 5B).

Figure 5C shows the author co-citation network diagram, the higher the weight of the co-cited author, the larger the label, and circle of the item. In the research field of TME, the top five influential authors are Professor R.J. Heald from the UK, Professor Ellen Kapiteijn, from the Netherlands, Professor Roman Sauer from Germany, and Professor I.D. Nagtegaal from the Netherlands, and Professor Koen Peeters from the Netherlands. Consistent with the author co-citation network diagram, in the author co-citation timeline diagram (Fig. 5D), the articles published by the above authors have been frequently cited for a long period.

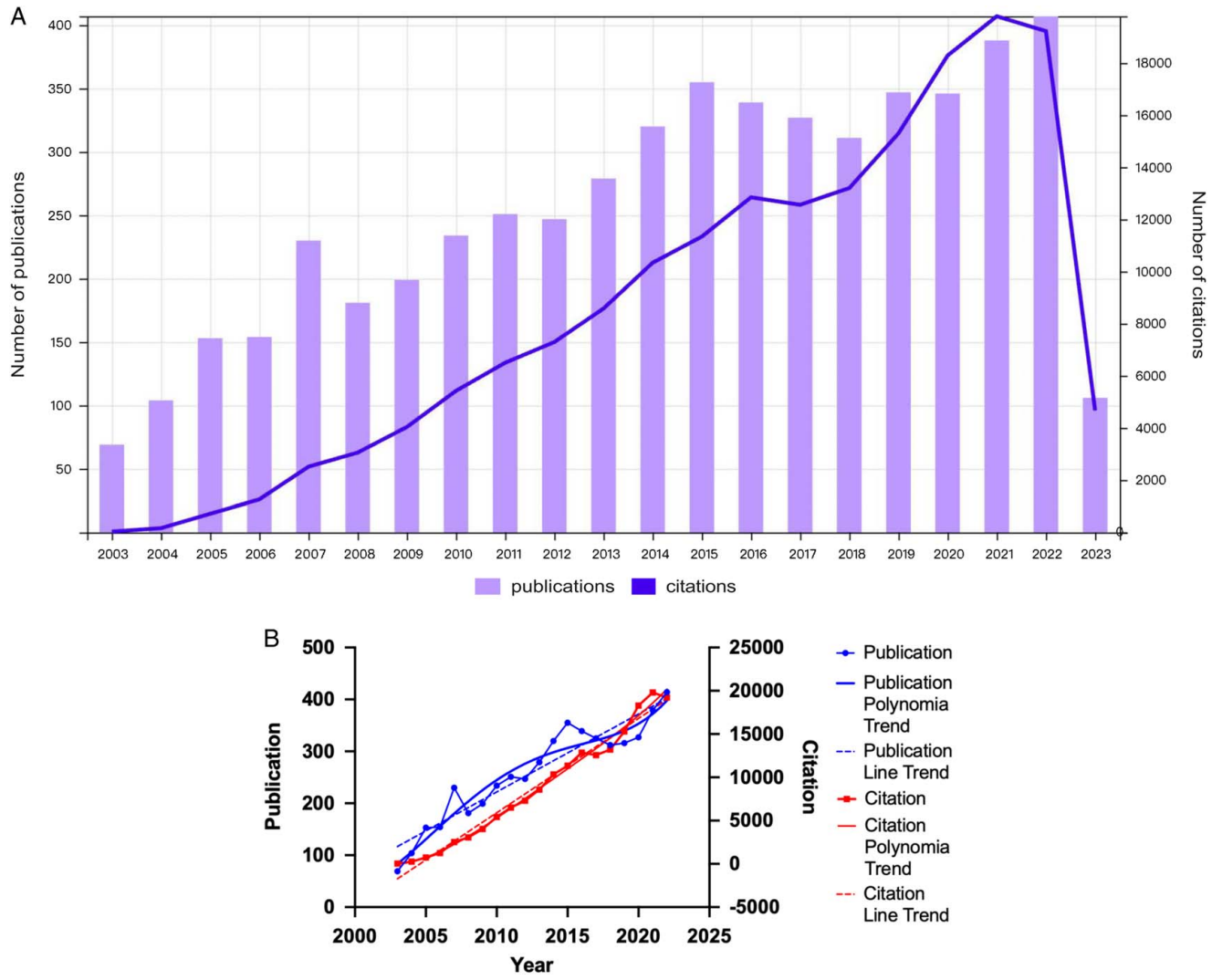

Figure 2. Annual publications, citations, and fitting curves. (A) 2003–2023 annual publications and citations; (B) The trend curve fitted according to the number of publications and the number of citations. The linear model of the number of publications: 'Y = 15.01 × X-29955', $R^2 = 0.8979$, the 'centered fourth order polynomial' model of the number of publications: 'Y = 282.5 + 12.05 × X-1.148 × X^2 + 0.04968 × X^ 3 + 0.007607 × X^4', $R^2 = 0.9347$; linear model of citation: 'Y = 1090 × X -2184907', $R^2 = 0.0.9804$, 'centered fourth order polynomial' model of citation: 'Y = 8116 + 1144. × X + 2.915 × X^2-0.9129 × X^3 + 0.2095 × X^4", $R^2 = 0.9908$.

Analysis of journals

The dual-map overlay of journals in Figure 6 shows the topic distribution of journals. The citing journals are on the left side of the map, and the cited journals are on the right. The tags represent the journals covered by the subject. From left to right, colored lines delineate reference paths. There are two different citation paths. Two green citation paths indicate that research in health/exercise/medicine/nursing journals is frequently cited by research in physiology/medicine/clinical journals.

Citation analysis

Citation analysis results are shown in Figure 7 and Table 2. Among the 10 most cited documents (Fig. 7B, Table 2), seven articles are randomized controlled trial (RCT), all published in high-quality journals: *Lancet* (two articles, IF = 168.9); *New England journal of medicine* (one article, IF = 158.5); *Lancet Oncology* (two articles, IF = 51.1); *Journal of clinical oncology: official journal of the American Society of Clinical Oncology* (two articles, IF = 45.3). '*Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial*' published by Professor Pierre J. Guillou's team in 2005 ranked first with a total of 2324 citations.

Keyword analysis

Figure 8A depicts a network of co-occurring keywords that reflect ongoing research hotspots in the field of TME. The co-occurring keywords were analyzed using the log-likelihood ratio to generate eight clusters, namely: 'locally advanced rectal cancer', 'robotic surgery', 'local recurrence', 'anastomotic leakage', 'sexual dysfunction', 'colorectal cancer', 'transanal endoscopic microsurgery', 'postoperative adjuvant chemotherapy'(Fig. 8B).

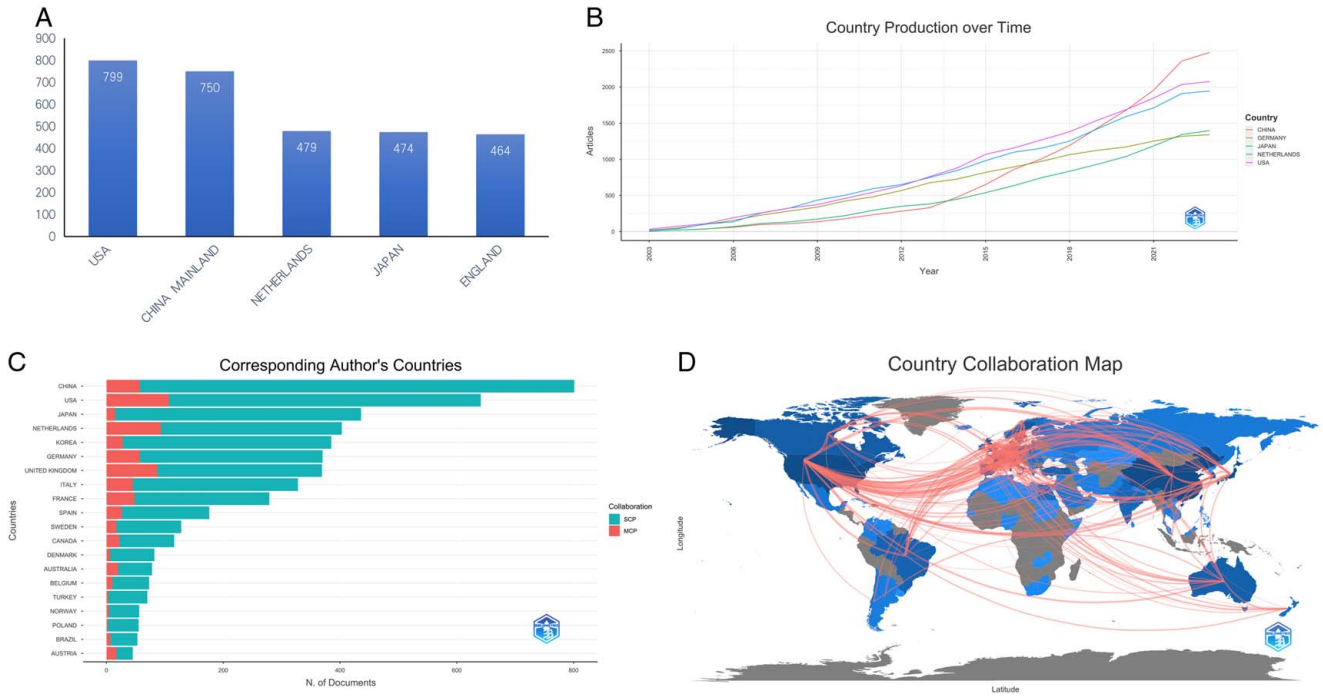

Figure 3. Analysis of countries/regions engaged in total mesorectal excision research. (A) Top 5 countries/regions with the largest number of publications; (B) Top 5 countries with the largest number of publications over time, MCP, multiple countries publication; SCP, single countries publication; (C) corresponding author's countries; (D) country cooperation network.

In the timeline graph containing clustering information (Fig. 9A) and the top 25 keywords with the strongest citation frequency (Fig. 9B), the focus of attention has shifted from traditional cancer itself to the care of patients, and the treatment methods have changed from the traditional form such as radiotherapy and chemotherapy to seeking more advanced surgical procedures, the research ideas have also undergone a transformation from randomized trials to multicenter studies, and more follow the guidance of clinical guidelines. In addition, robotic surgery has also opened up new ideas and created new possibilities for traditional surgical treatment methods in recent years.

Table 1

Corresponding author's countries.

Country	Articles	Single countries publication	Multiple countries publication	Freqncy	Multiple countries publication ratio
Austria	45	28	17	0.008	0.378
Australia	78	58	20	0.015	0.256
United Kingdom	369	282	87	0.069	0.236
Netherlands	403	310	93	0.075	0.231
Canada	116	94	22	0.022	0.19
France	279	231	48	0.052	0.172
USA	641	534	107	0.12	0.167
Germany	370	313	57	0.069	0.154
Spain	176	150	26	0.033	0.148
Italy	328	283	45	0.061	0.137
Belgium	73	63	10	0.014	0.137
Sweden	128	111	17	0.024	0.133
Brazil	53	46	7	0.01	0.132
Korea	385	357	28	0.072	0.073
Denmark	82	76	6	0.015	0.073
China mainland	801	744	57	0.15	0.071
Norway	56	52	4	0.01	0.071
Turkey	70	67	3	0.013	0.043
Poland	55	53	2	0.01	0.036
Japan	436	421	15	0.082	0.034

Discussion

In 1982, Heald *et al*. proposed TME for the treatment of rectal cancer and put it into clinical use, which greatly improved the prognosis of rectal cancer patients. Kapiteijn *et al*.[33] proposed neoadjuvant radiotherapy on the basis of TME, which laid the foundation for basic strategies in the treatment of rectal cancer, so research on TME and neoadjuvant radiotherapy continues to this day. In this study, we searched the WOS core collection and screened for 5345 publications on TME between 2003 and 2023. In terms of annual publications, although the total number of publications has fluctuated in the past 20 years, the overall number has risen steadily. Citations have also been on the rise for 20 years. A growing number of publications and citations indicate that research on TME is receiving increasing attention.

In terms of national and regional distribution, the Netherlands has been one of the countries with the highest contribution to TME research in the past two decades, which is reflected in the number of publications and the frequency of citations. In the past 20 years, the number of articles published by Chinese scholars has come from behind, with the most rapid increase. This may be related to the dramatic increase in the incidence and population of CRC in China, raising more attention among Chinese doctors.

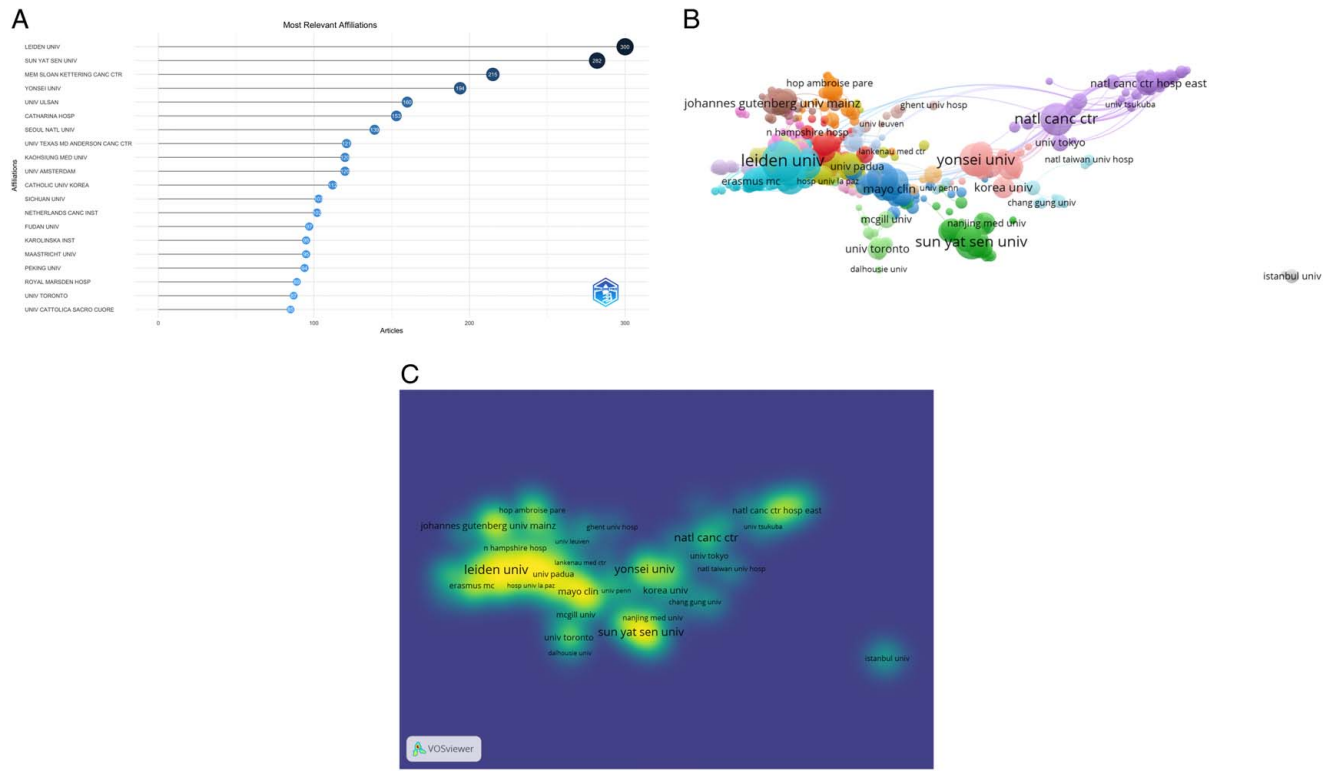

Figure 4. Analysis of institutions engaged in total mesorectal excision research. (A) the 20. institutions with the largest number of publications; (B) institutional cooperation network; (C) the authorization of organizations.

Traditionally, we believe that CRC is related to genetic background[34], recent studies have shown that CRC is closely related to eating habits and being overweight[35,36], the presence of overweight/obesity 8–10 years before the diagnosis of CRC was shown to be associated with a 27–109% increased risk of CRC[37]. In addition, changes in the lifestyle of the population may also lead to more CRC cases. Although the United States has the largest number of publications and the largest number of overseas collaborative publications, the latter is far less than the number of independent publications by domestic scholars. The UK and the Netherlands have more exchanges and cooperation with other countries, and there are more high-quality publications in the two countries. The frequency of citations of publications is at the forefront, and they have a greater influence on the research of the TME field. Therefore, in the follow-up research, China and the United States need to continue to strengthen exchanges and cooperation with other countries/institutions while maintaining close cooperation between the two countries, so as to produce more high-quality publications. As one of the countries with the most far-reaching influence in the field of TME research, the Netherlands' domestic Leiden University has undoubtedly made great contributions. Among the top 20 institutions with the most articles, five institutions are from the Netherlands, and Leiden University ranks first. Although China also has five institutions that belong to the top 20 institutions with the most published articles and have made considerable contributions in the field of TME research, there is still a relatively large gap compared with institutions in the Netherlands. Therefore, Chinese institutions and researchers urgently need to strengthen exchanges and cooperation with other institutions and scholars, improve research levels, and produce more high-quality articles.

Professor R.J. Heald from the United Kingdom ranks first among all cited authors because he made a milestone contribution to the emergence of the new research field of TME. Heald and his team proposed the use of TME technology in 1982, which later became the world-recognized surgical treatment of rectal cancer. In 1992, Heald and his team reported TME in 169 patients with rectal cancer, of which 152 were classified as curative, 110 had a resection margin greater than 1 cm, and 42 had a resection margin less than or equal to 1 cm. There was no statistically significant difference in the local and distant recurrence rates between the two groups[38]. Therefore, the surgical principle of TME is reasonable, and it can resect rectal cancer and its local infiltrating lesions[39,40]. Then, the researchers extended this study, Ellen Kapiteijn, and Roman Sauer, I.D. Nagtegaal, and Koen Peeters *et al.* pointed out that TME preoperative radiotherapy can help reduce tumor local recurrence, and their study established the advantage of neoadjuvant radiotherapy over postoperative adjuvant radiotherapy, consolidating the position of neoadjuvant radiotherapy in the treatment of colorectal cancer[27,29,33,41]. Their outstanding contributions to the field of TME research have promoted the development of this field. From the results, although TME was first proposed by a British author, Dutch authors have done more multicenter studies and obtained a higher-level of clinical evidence, so there are more Dutch authors who are influential in the field of TME research. At present, the cooperation between research teams/laboratories conducting TME-related research on a global scale has not been well established, and the connection between clusters is not close.

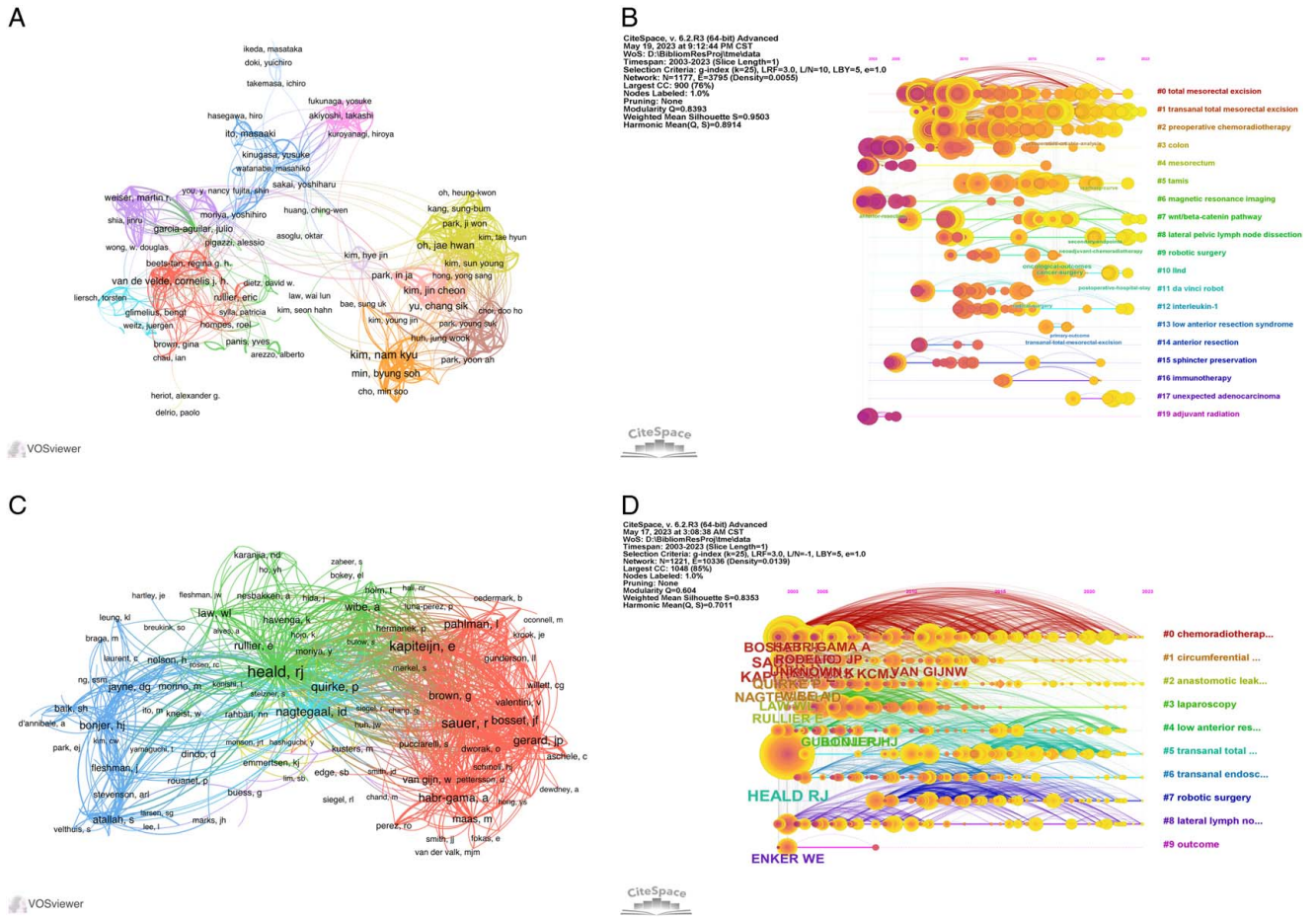

Figure 5. Analysis of authors engaged in total mesorectal excision research. (A) author's cooperation network; (B) timeline chart of the author's cooperation; (C) author co-citation network; (D) timeline chart of the author co-citation.

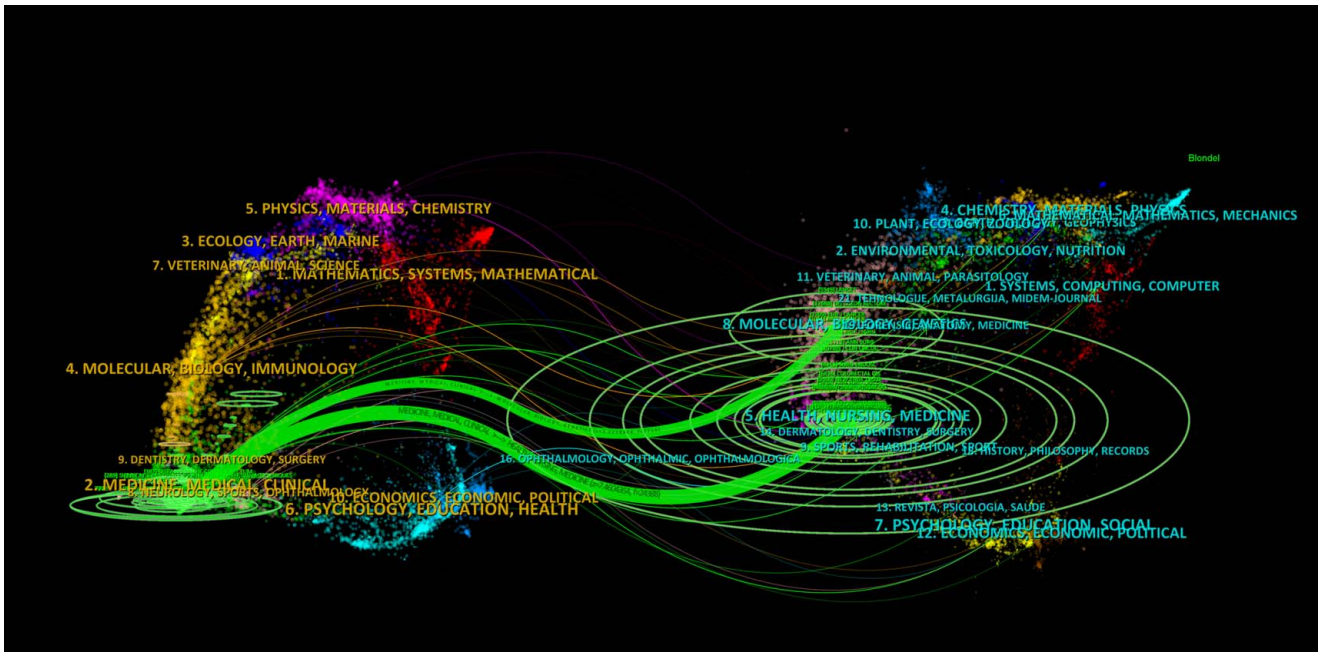

Figure 6. Dual map overlay for journals.

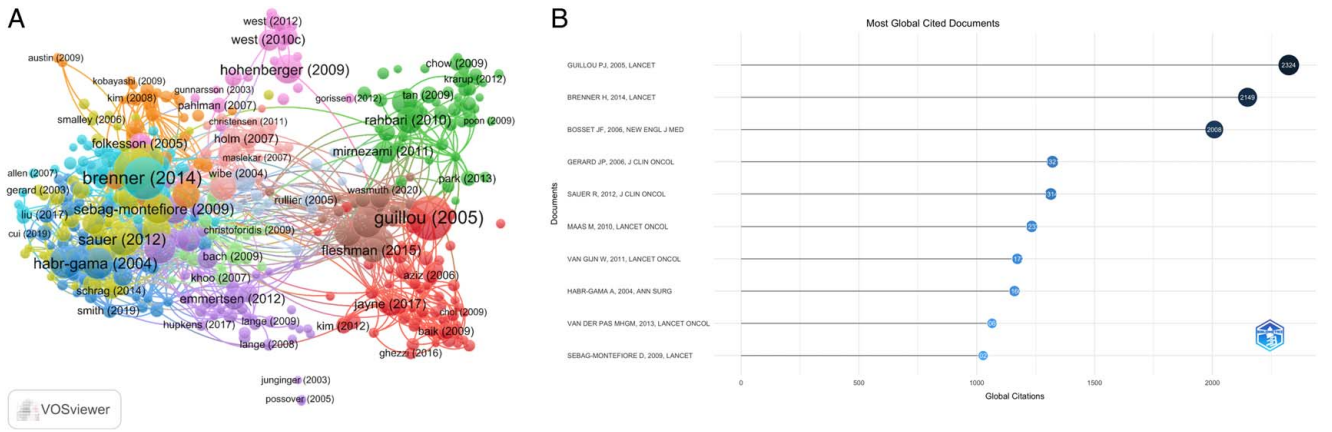

Figure 7. Analysis of citations engaged in total mesorectal excision research. (A) co-citation network; (B) top 10 most cited papers.

This partly explains the mismatch between the number of publications and the number of citations in China and calls for scientists from all over the world to break down boundaries and bring about deeper cooperation. Only in this way can hot issues in the field be predicted while broadly influencing future developments. Only by carrying out multicenter research and obtaining higher-level clinical evidence can we better guide clinical practice.

Highly cited documents are published in journals with high-impact factors, most of which are prospective RCTs, and the evidence level is high. These highly cited RCT articles all adopt the intention to treat analysis method and obtain relatively conservative research results: short-term outcomes[31], 3-year local recurrence rates, and 5-year disease-free survival rates were similar between the open and laparoscopic groups[23]. The ten-year cumulative incidence of distant metastases and disease-free survival did not differ between the preoperative and post-operative CRT groups[27]. In patients with stage 0, good long-term outcomes can be obtained after neoadjuvant CRT with or without surgery[30]. However, among stage III patients, the 10-year local recurrence rate was significantly less in patients who received short-term preoperative radiotherapy combined with surgery than in patients who received surgery alone[29,32]. The results of previous studies show that there is still controversy in the choice of treatment for rectal cancer, suggesting that more multicenter prospective RCTs are needed in the future to obtain more reliable clinical evidence. In addition, although evidence-based medicine uses RCT as the 'gold standard' of evidence, RCT also has limitations. In daily clinical diagnosis and treatment, not all patients meet the strict inclusion and exclusion criteria of RCT studies. A real-world study[42] can not only reduce the limitations of traditional research but also reflect the clinical efficacy of treatment measures in the real-world, providing an objective comparative basis for the selection of treatment methods in clinical treatment. Through real-world data, we can fully understand the gap between guidelines and practice, and provide reference for the formulation and specification of guidelines. Therefore, researchers are encouraged to conduct more real-world study in future clinical research on the basis of a multicenter prospective RCT.

The development process and recent research hotspots of the research field on colorectal cancer treatment can be seen from the timeline diagram of author cooperation and keywords and the top 25 keywords with the highest citation frequency. The colon, rectum, and anatomy were the first to be studied. Immediately afterward, robotic surgery, TaTME, and laparoscopic TME became research hotspots. Also developed together is basic research on the mechanism of rectal cancer and research on 'low anterior resection syndrome' including 'anastomotic leakage', 'sexual dysfunction', and 'local recurrence'. Current surgical treatment methods for rectal cancer include open, laparoscopic, and robotic surgery. The choice of procedure is determined by surgeon and patient preference, as there is no evidence that one method is superior to the other[31,43–45]. To highlight the specific role of each technique, clinicians have performed a more nuanced study of surgical approaches for rectal cancer. A prospective study showed that compared with robotic TME, TaTME is especially suitable for surgical treatment of low rectal cancer , while robotic TME treatment is more likely to improve the distance of the distal resection margin and shorten the hospital stay[46,47]. In general, TME surgery should only be performed by experienced surgeons. According to the National Comprehensive Cancer Network clinical practice guidelines in oncology (NCCN guidelines), patients with high-risk circumferential margins or acute bowel obstruction or perforation from rectal cancer should undergo open surgery[48].

In recent years, due to the in-depth study of membrane anatomy theory[49] and the improvement of surgical skills, individualized lymph node dissection after TME treatment of rectal cancer has become a new research hotspot. And thanks to the application of new comprehensive treatment methods, more rectal cancer patients can preserve the anus, and anus-preserving low rectal cancer resection is also a technical improvement that clinicians are constantly pursuing. However, up to 60–90% of patients may experience varying degrees of intestinal and anal dysfunction after anus-sparing surgery[50,51]. Some adjuvant therapies such as ramosetron and pelvic floor muscle training can benefit patients with low anterior resection syndrome in the short-term[52,53], while some other treatments like transcutaneous electrical nerve stimulation and oral probiotics may not affect the outcome[54,55]. Therefore, it is necessary to explore new surgical treatment methods for rectal cancer in order to reduce the

Table 2

Top 10 most cited publications.

Rank	Representative author	Title	Total citations	Journal		Type of research
				Name	IF(2022)	
1	Guillou[23]	Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial (2005)	2324	*Lancet*	168.9	Randomized controlled trial
2	Brenner[24]	Colorectal cancer (2014)	2149	*Lancet*	168.9	Review
3	Bosset[25]	Chemotherapy with preoperative radiotherapy in rectal cancer (2006)	2008	*New England journal of medicine*	158.5	Randomized controlled trial
4	Gérard[26]	Preoperative radiotherapy with or without concurrent fluorouracil and leucovorin in T3-4 rectal cancers: results of FFCD 9203 (2006)	1321	*Journal of clinical oncology: official journal of the American Society of Clinical Oncology*	45.3	Randomized controlled trial
5	Sauer[27]	Preoperative versus postoperative chemoradiotherapy for locally advanced rectal cancer: results of the German CAO/ARO/AIO-94 randomized phase III trial after a median follow-up of 11 years (2012)	1314	*Journal of clinical oncology: official journal of the American Society of Clinical Oncology*	45.3	Randomized controlled trial
6	Maas[28]	Long-term outcome in patients with a pathological complete response after chemoradiation for rectal cancer: a pooled analysis of individual patient data (2010)	1233	*Lancet. Oncology*	51.1	Meta-analysis
7	Gijn[29]	Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer: 12-year follow-up of the multicentre, randomised controlled TME trial (2011)	1172	*Lancet. Oncology*	51.1	Randomized controlled trial
8	Gama[30]	Operative versus nonoperative treatment for stage 0 distal rectal cancer following chemoradiation therapy: long-term results (2004)	1160	*Annals of surgery*	9	Cohort study
9	Martijn Hgm van der Pas[31]	Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial (2013)	1065	Lancet. *Oncology*	51.1	Randomized controlled trial
10	Montefiore[32]	Preoperative radiotherapy versus selective postoperative chemoradiotherapy in patients with rectal cancer (MRC CR07 and NCIC-CTG C016): a multicentre, randomised trial	1027	*Lancet*	168.9	Randomized controlled trial

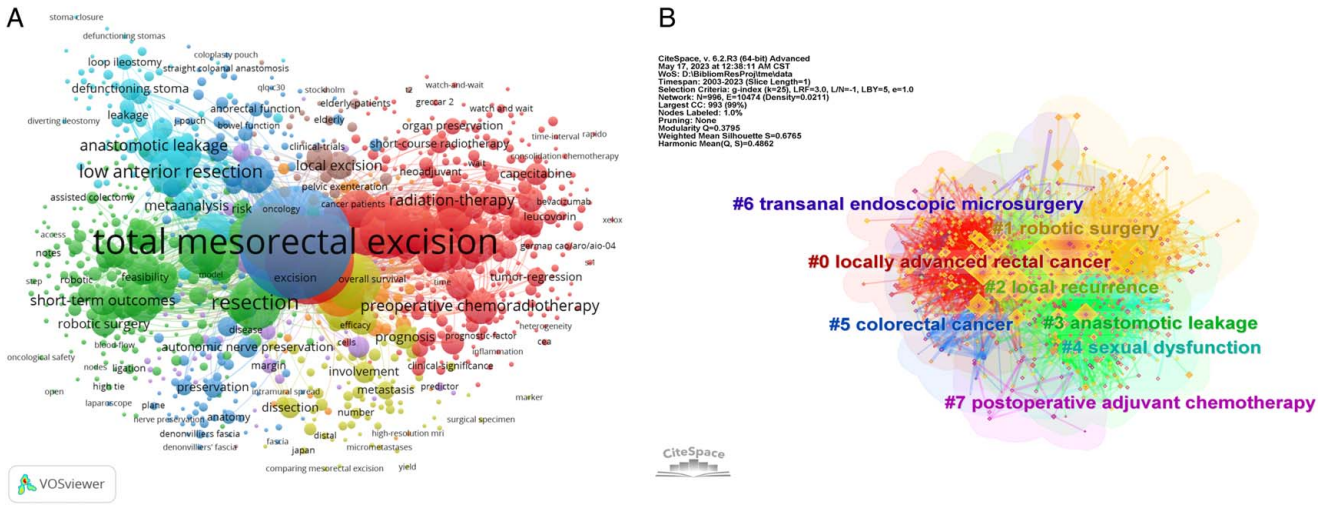

Figure 8. Analysis of keywords engaged in total mesorectal excision research (A) keyword co-occurrence network; (B) keyword cluster analysis.

occurrence of postoperative complications and improve the quality of life of patients.

In addition, telemedicine and the multidisciplinary cooperation represented by 'robotic surgery' may be potential directions for future research. Especially in an environment encouraging medical-industrial integration and the vigorous development of rehabilitation medicine, studies have shown that digital health plays a significant role in supporting the mental health of cancer patients. Digital health can not only improve the efficiency of hospitals in managing cancer patients but also empower patients with greater independence and self-acceptance[56]. Research by Tabriz *et al.*[57] shows that CRC survivors can help rebuild a healthier lifestyle via diet, adherence to treatment, regular physical activity, and good sleep habits. In addition, effective social support, spiritual growth, and treatment of psychological disorders can facilitate their recovery. Therefore, it is necessary to encourage and promote academic exchanges between scholars in related fields in various countries, develop domestic and foreign cooperative relations, improve scientific research, share research results, and jointly promote the development of colorectal surgery.

The present study has some limitations. All these bibliographic data were retrieved from the Web of Science (WoS) Core Collection. Although the WoS Core Collection contains more than 11 000 authoritative and high-impact international academic journals, with a wide coverage and powerful analysis functions, there may still be articles missing in other database resources due to the relatively single source. In addition,

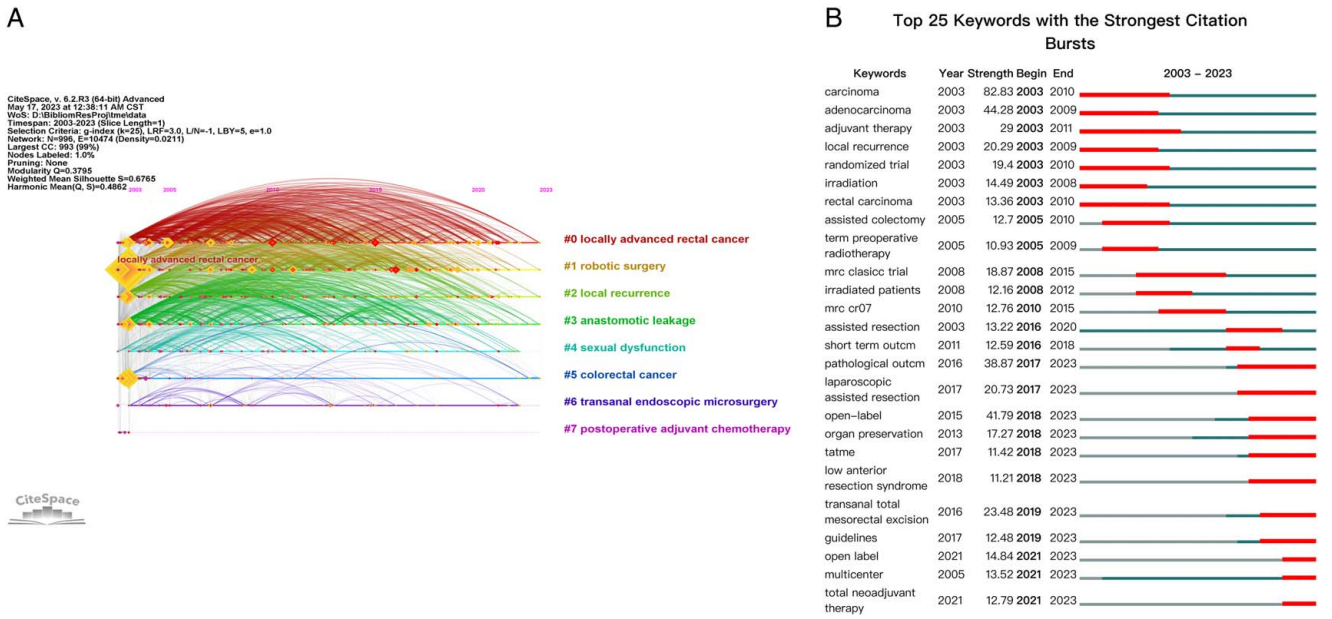

Figure 9. (A) Timeline chart of the keyword; (B) the top 25 keywords with the strongest citation bursts.

researchers manually removed papers that were considered not relevant to the study objective, which could lead to selection bias. Nevertheless, our study offers a thorough analysis of the present state of TME research and the advancements made in CRC patients between 2003 and 2023, assisting in the identification of future research directions.

Conclusion

The United States and China are the regions with the most prolific research on TME. The most influential country in the field of TME research is the Netherlands, and the most influential author is R.J. Heald. The focus of keyword research has gradually shifted from the pursuit of clinical cures to efforts to improve the quality of life of patients after surgery. The results of the citation analysis show that the choice of TME method is still controversial, calling on researchers to vigorously carry out high-quality RCTs and real-world studies in order to seek higher quality and effective clinical evidence. In addition, it is also recommended to focus on promising research hotspots, such as telemedicine, interdisciplinary, and medical-industrial integration, etc. Our study provides insight into the research history and current status of TME, which may herald its future development trend.

Ethical approval

The data source for our paper is Web of Science, which is publicly available data, and ethical approval is not applicable to this paper.

Consent

This article does not refer to any research on patients or volunteers.

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Author contribution

M.L., X.D., and Y.P.: were responsible for the design, analysis, and writing; Y.P. and X.C.: acquired the data, related materials, and analysis tools; Y.P., X.D., and X.C.: analized data; Y.P. and X.D.: wrote the paper; Y.P., X.D., and M.L.: revised the paper.

Conflicts of interest

The authors declare that there is no conflicts of interest regarding the publication of this paper.

Research registration unique identifying number (UIN)

The research in this article does not involve human studies, so UIN does not apply to this article.

Guarantor

Moubin Lin and Yun Pan are the guarantors for this article.

Data availability statement

All the data used in this study are from Web of Science, and the data are reflected in the text of the article, pictures, and tables.

Provenance and peer review

This paper was not invited.

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