



The Most Influential Publications on Endoscopic Submucosal Dissection: A Bibliometric Analysis

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Background/Aims: Endoscopic submucosal dissection (ESD) is the first-line treatment for superficial gastrointestinal neoplasms with negligible lymph node metastasis. It has evolved through improvements in expertise and equipment, increased understanding of indications and short- and long-term outcomes, and better management of complications. This study aimed to assess and characterize the most influential publications in ESD research.

Materials and Methods: We searched the top 50 most cited articles using Web of Science Core Collection (WoSCC) and Google Scholar (GS) from the inception of these services to January 2019. The top 50 Altmetric Attention Score (AAS) articles based on online media mentions were also searched. Each article was evaluated for the number of citations, title, journal, and publication year.

Results: The number of citations for the top 50 WoSCC articles on ESD ranged from 37 to 199; Endoscopy published the most articles (20%). Among the top 50 GS articles, Gastrointestinal Endoscopy published the most ESD articles (34%) and the most shared AAS articles (42.6%). PubMed Central article citations in WoSCC or GS showed significant correlation with those from each metric, unlike AAS. The words with the highest relevance scores were “submucosal tunnel dissection,” “guideline,” “novel submucosal gel,” “adhesive material,” “cell sheet,” “esophageal ulcer,” “hemostatic,” and “endoscopic closure,” while the following words were influential: “meta-analysis,” “esophageal stricture,” “perforation,” “bleeding,” “fibrin glue,” “artificial ulcer,” “porcine model” and “esophageal squamous cell neoplasia,” excluding “ESD.”

Conclusions: This study presents a detailed list of influential articles, journals, and topic words. (**Korean J Helicobacter Up Gastrointest Res 2020;20:306-317**)

Key Words: Bibliometrics; Endoscopic submucosal dissection; Publications; Research

INTRODUCTION

Academic impact of publication is frequently reflected by the number of times the publication is included as a citation.¹ As the amount of newly published literature that researchers need to be aware of increases and the importance of selective searching and summarization grows, the meaning of citation counts as a bibliometric index is growing. Many milestones of literature have dramatically influenced the promotion of specific research fields, and there are many cases in which the impact of older publications does not diminish. However, there has been little work in the identification of influential literature in the

field of gastroenterology.

Citation counts have been the most widely adopted and useful method for measuring the impact of research activity. However, it has been criticized because the citation only occurs for a certain amount of time after publication, leaving influential literature uncited in many cases. It is also impossible to recognize the reasons the literature is cited, whether to express support or to criticize the content of the text. Moreover, solely examining citation frequency is inadequate to measure the impact beyond the particular academic field.

Social media influence in medicine is growing.² The current production of knowledge and distribution of data is frequently mediated by social media in the form of unstructured text data, rather than the traditional journal form.³ Medical knowledge is no longer only limited to experts and is accessible for patients to share and disseminate. With the widespread use of social media, a new concept of social web-based

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metrics ('altmetrics') has been implemented as an indicator that more quickly reflects influence and attention than traditional indicators.⁴ Altmetric Attention Score (AAS) accounts for the scientific and social impact of an article after publication and is based on the weighted count of 'mentions' of an article across various online sources while reflecting the relative reach of each type of source.^{4,5}

Endoscopic submucosal dissection (ESD) is the established treatment for superficial gastrointestinal neoplasms with minimal risk of lymph node metastasis. The most important advantage of this procedure was in achieving curative resection with minimal invasiveness, avoiding invasive surgery that inevitably accompanies substantial morbidity. It has emerged and evolved through an improvement of skills, expertise, and equipment, to arrive at a better understanding of indications, short- and long-term outcomes, and management of complications. This study aimed to assess and characterize the most influential publications in ESD research.

MATERIALS AND METHODS

1. Selection of bibliometric tools

To conduct a citation analysis in the field of ESD research, we selected the following three representative bibliometric tools: Web of Science Core Collection (WoSCC; Clarivate Analytics, Philadelphia, PA, USA), Google Scholar (GS; Google LLC., Mountain View, CA, USA), and Altmetric Explorer (Altmetric LLP, London, UK).

The WoSCC is an online scientific indexing platform that provides a comprehensive citation searching mechanism for their collection of high-quality scholarly content, providing access to multiple databases for research discovery, covering multidisciplinary content,⁶ which allows for an in-depth exploration of specialized academic fields. The WoSCC search of the top 50 most-cited articles was able to retrieve articles published from 2013 to 2017 and included relatively recent citations from high-quality journals that have been integrated annually from Journal Citation Reports (JCR) (timespan option of searching was set for all years).

GS is an online search engine that indexes publications

from academic and scientific web domains. It provides bibliographic references and citations from most peer-reviewed online academic journals, books, conference papers, theses, dissertations, preprints, and court opinions and patents.⁷ GS has indexed approximately 389 million documents, making it the world's largest academic search engine as of January 2018.⁸ Researchers can also obtain information from non-JCR journals.⁹ Harzing's Publish or Perish software is a third party tool for calculating numbers of citations that could retrieve articles published from 1999 to 2015, pulling citations from various sources, not limited to JCR journals and recent research.¹⁰

Altmetric.com provides real-time online mentions of published articles from public policy documents, mainstream media, online reference managers, post-publication peer-review platforms, Wikipedia, Open Syllabus Project, patents, blogs, research highlights from F1000Prime, and social media platforms, including Facebook, Twitter, and YouTube, from 2011.⁴ It provides AAS to measure the overall level of online impact using Altmetric Explorer.⁴

PubMed is the most widely used tool for searching medical literature. Since it does not provide a tool for analysing the citation counts by bibliometric index, it was used to validate the citation counts of WoSCC and GS.

2. Identification of the top 50 most-cited articles and the top 50 most-mentioned AAS articles in online media

We searched the top 50 most-cited articles using the WoSCC and GS from the inception of these services to January 2019 with two independent evaluators (YJY and CSB). The search term was 'endoscopic submucosal dissection'. The site was accessed on 1 February 2019 to avoid changes in the online activity of publications. Articles with the same number of citation counts were included in the analysis even if the number of enrolled articles exceeded 50. Then, we performed a comparison of the citation counts for the top 50 articles from WoSCC and GS with those of PubMed Central (PMC), using the PubMed platform on the same day. Since the publication dates of the GS top 50 most-cited articles ranged from 1999 to 2015, it was difficult to reflect recent citations.

Therefore, the top 50 articles published after 2015 among the top 1,000 most-cited articles according to GS bibliometrics were extracted and analysed separately. AAS was also accessed and retrieved on 1 February 2019 using the 'advanced search' function in Altmetric Explorer.

All articles were retrieved and ranked in descending order based on the citation counts obtained by WoSCC, GS, and AAS. The titles and abstracts of all identified ar-

ticles were reviewed to exclude irrelevant publications. Publications relevant to ESD, such as endoscopic mucosal resection (EMR), peroral endoscopic myotomy (POEM), or submucosal tunnel dissection, were included. Full-text reviews were conducted for cases where it was impossible to determine the relevance of ESD research. Disagreements between the evaluators were resolved by discussion.

Table 1. The Top 10 Most-cited Articles of WoSCC Bibliometrics in ESD Research (2013~2017)

Rank	First author	Journal	Title	Citation counts (WoSCC)	Citation counts (PMC)	Stomach vs. colon vs. esophagus vs. duodenum	Type of article
1	Pimentel-Nunes P	Endoscopy 2015;47:829-854	Endoscopic submucosal dissection: European Society of Gastrointestinal Endoscopy (ESGE) guideline	199	78	All	Guideline/consensus report
2	Tanaka S	Dig Endosc 2015;27:417-434	JGES guidelines for colorectal endoscopic submucosal dissection/endoscopic mucosal resection	140	48	Colon	Guideline/consensus report
3	Toyonaga T	Surg Endosc 2013;27:1000-1008	1,635 Endoscopic submucosal dissection cases in the esophagus, stomach, and colorectum: complication rates and long-term outcomes	105	35	All	Original research
4	Ono H	Dig Endosc 2016;28:3-15	Guidelines for endoscopic submucosal dissection and endoscopic mucosal resection for early gastric cancer	85	30	Stomach	Guideline/consensus report
4	Fujiya M	Gastrointest Endosc 2015;81:583-595	Efficacy and adverse events of EMR and endoscopic submucosal dissection for the treatment of colon neoplasms: a meta-analysis of studies comparing EMR and endoscopic submucosal dissection	85	22	Colon	Original research (systematic review/meta-analysis)
6	Lee EJ	Surg Endosc 2013;27:31-39	Endoscopic submucosal dissection for colorectal tumors--1,000 colorectal ESD cases: one specialized institute's experiences	83	29	Colon	Original research
7	Nishiyama N	World J Gastroenterol 2013;19:2752-2760	Efficacy and safety of over-the-scope clip: including complications after endoscopic submucosal dissection	80	35	All	Original research
7	Oda I	Dig Endosc 2013;25 Suppl 1:71-78	Complications of gastric endoscopic submucosal dissection	80	35	Stomach	Review
9	Probst A	Endoscopy 2015;47:113-121	Early esophageal cancer in Europe: endoscopic treatment by endoscopic submucosal dissection	70	33	Esophagus	Original research
10	Abe S	Endoscopy 2013;45:703-707	Short- and long-term outcomes of endoscopic submucosal dissection for undifferentiated early gastric cancer	69	33	Stomach	Original research

The top 10 most cited articles of WoSCC bibliometrics in ESD research (2013~2017).

WoSCC, Web of Science Core Collection; ESD, endoscopic submucosal dissection; PMC, PubMed Central; EMR, endoscopic mucosal resection.

3. Data extraction and bibliometric analyses

Each of the top 50 most-cited or -mentioned articles was examined for 1) citation counts from WoSCC, GS, and from PMC articles; 2) AAS; 3) title; 4) journal name with its impact factor and Eigenfactor™ score;¹¹ 5) published year; 6) region (stomach vs. colon vs. esophagus vs. duodenum vs. all regions) of ESD; and 7) article type (original research vs. guideline/consensus report vs. review vs. case report).

A network-analysis was conducted to determine the most influential words in titles, abstracts, and of both titles and abstracts among the top 500 most-cited articles in WoSCC. Visualization was impossible when analysing the top 50 most-cited articles due to paucity of data; therefore, the analysis scheme was increased to the top 500 most-cited articles.¹² The units of analysis were words in a title or abstract, and a full counting method was adopted—all occurrences of a term in a title or abstract were counted.

4. Statistical analyses

This study's primary outcome was a narrative synthesis

of data. However, a quantitative synthesis was conducted to find correlations between citation counts from WoSCC or GS and those from PMC articles. The correlation coefficient was analysed using Pearson's correlation test; the partial correlation coefficient was analysed to control for confounding variables. To find the differences in citation counts according to the publication year, a Kruskal-Wallis test was performed. To find the differences in publication numbers of different regions of ESD according to the publication year, a Cochran-Armitage test for trend was executed. Harzing's Publish or Perish software version 6 was used for the citation analysis,¹⁰ and VOSviewer version 1.6.9 was used for the network analysis.¹² A *P*-value <0.05 (two-tailed) was defined as the statistical significance threshold for all tests. All analyses were performed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA), except for the Cochran-Armitage test, which was completed using EpiTools calculators (<http://epitools.ausvet.com.au/content.php?page=trend>; Ausvet Pty Ltd, Bruce, Australia).

Table 2. Journals with Two or More of the Top 50 Most-cited Articles of WoSCC Bibliometrics in ESD Research

Rank	Journal	Number of published articles in each journal among the top-50 cited articles	Journal impact factor based on JCR 2017	Eigenfactor™ score	Category by JCR
1	Endoscopy	10	6.629	0.018	Gastroenterology & hepatology/surgery
2	Digestive Endoscopy	9	3.375	0.005	Gastroenterology & hepatology/surgery
2	Gastrointestinal Endoscopy	9	7.204	0.034	Gastroenterology & hepatology
4	Surgical Endoscopy and Other Interventional Techniques	6	3.117	0.042	Surgery
5	Gastric Cancer	4	5.045	0.007	Gastroenterology & hepatology/oncology
6	World Journal of Gastroenterology	3	3.300	0.058	Gastroenterology & hepatology

Impact factor measures the number of citations to the journal in a given year by the number of articles published in that journal in the previous 2 years. Eigenfactor™ score is calculated based on the number citations to the journal in a given year by the number of articles published in that journal in the past 5 years. Unlike the 5-year journal impact factor, the Eigenfactor™ score excludes self-citation and assigns weight to each earned citation according to the citedness of the citing journal.¹¹

WoSCC, Web of Science Core Collection; ESD, endoscopic submucosal dissection; JCR, journal citation reports.

RESULTS

1. Bibliometrics of WoSCC

Table 1 lists the top 10 most-cited articles from WoSCC and Supplementary File 1 lists the top 50 most-cited articles from WoSCC including detailed information. The citation counts for the top 50 articles ranged from 37 to 199; the publication years ranged from 2013 to 2017. The top 50 articles were published in 15 different journals; Endoscopy

published the largest share of articles (20%), followed by Digestive Endoscopy/Gastrointestinal Endoscopy (18%) (Table 2).

In the WoSCC bibliometrics of the top 50 most-cited articles, citations from PMC articles showed a significant correlation with those from WoSCC ($r=0.93$, $P<0.001$). The result was consistent after controlling for publication year, region of ESD, and type of article (partial correlation coefficient=0.94, $P<0.001$). A Kruskal-Wallis test showed no significant difference ($P=0.12$) in citation counts ac-

Table 3. The Top 10 Most-cited Articles of Google Scholar Bibliometrics in ESD Research (1999~2015)

Rank	First author	Journal	Title	Citation counts (Google Scholar)	Citation counts (PMC)	Stomach vs. colon vs. esophagus vs. duodenum	Type of article
1	Inoue H	Endoscopy 2010;42:265-271	Peroral endoscopic myotomy (POEM) for esophageal achalasia	1,195	171	Esophagus	Original research
2	Gotoda T	Gastric Cancer 2007;10:1-11	Endoscopic resection of early gastric cancer	667	137	Stomach	Review
3	Gotoda T	J Gastroenterol 2006;41:929-942	Endoscopic submucosal dissection of early gastric cancer	663	129	Stomach	Review
3	Oka S	Gastrointest Endosc 2006;64:877-883	Advantage of endoscopic submucosal dissection compared with EMR for early gastric cancer	663	138	Stomach	Original research
5	Oyama T	Clin Gastroenterol Hepatol 2005;3(7 Suppl 1):S67-S70	Endoscopic submucosal dissection of early esophageal cancer	581	129	Esophagus	Original research
6	Isomoto H	Gut 2009;58:331-336	Endoscopic submucosal dissection for early gastric cancer: a large-scale feasibility study	541	136	Stomach	Original research
7	Oda I	Dig Endosc 2005;17:54-58	Endoscopic submucosal dissection for early gastric cancer: technical feasibility, operation time and complications from a large consecutive series	530	Not available	Stomach	Original research
8	Chung IK	Gastrointest Endosc 2009;69:1228-1235	Therapeutic outcomes in 1000 cases of endoscopic submucosal dissection for early gastric neoplasms: Korean ESD Study Group multicenter study	505	125	Stomach	Original research
8	Saito Y	Gastrointest Endosc 2010;72:1217-1225	A prospective, multicenter study of 1111 colorectal endoscopic submucosal dissections (with video)	505	109	Stomach	Original research
10	Tanaka S	Gastrointest Endosc 2007;66:100-107	Endoscopic submucosal dissection for colorectal neoplasia: possibility of standardization	494	82	Colon	Original research

ESD, endoscopic submucosal dissection; PMC, PubMed Central.

ording to the publication year.

Of the top 50 most-cited articles, original research comprised 78%, review 14%, guidelines or consensus reports 6%, and case series 2%. The proportion of systematic reviews/meta-analyses was 8% (Supplementary File 1).

For the region of ESD in each study, stomach comprised 32%, colon 30%, esophagus 20%, all regions 12%, and duodenum 6%. A Cochran-Armitage test for trends showed no significant difference ($P=0.48$) in publication numbers on different regions of ESD from WoSCC according to the publication year.

2. Bibliometrics of GS

Table 3 lists the top 10 most-cited articles from GS, and Supplementary File 2 lists the top 50 most-cited articles from GS. The citation number for the top 50 most-cited articles found through GS ranged from 221 to 1,195 and the publication years ranged from 1999 to 2015. The top 50 most-cited articles were published in 12 different journals. Gastrointestinal Endoscopy published the largest share of articles (34%), followed by Endoscopy (22%) (Supplementary Table 1).

The GS bibliometrics of the top 50 most-cited articles indicated that the citations of PMC articles were significantly correlated with those from GS ($r=0.80$, $P<0.001$). The result was consistent after controlling for publication year, region of ESD, and type of article (partial correlation coefficient=0.81, $P<0.001$). A Kruskal-Wallis test showed no significant difference ($P=0.38$) in citation counts according to the publication year.

Original research comprised 90%, review 8%, guidelines or consensus reports 2%, and systematic reviews/meta-analyses 4% of the top-50 cited articles (Supplementary File 2).

For the region of ESD in each study, stomach comprised 50%, esophagus 24%, colon 16%, and all regions 10% of the top 50 most-cited articles of GS bibliometrics. A Cochran-Armitage test for trends showed no significant difference ($P=0.05$) in publication numbers on different regions of ESD from GS according to the publication year.

3. Bibliometrics of GS published after 2015

Among the top 1,000 most-cited articles on GS bibliometrics, there were 50 papers published between 2015 and 2017. Supplementary Table 2 lists the top 10 most-cited articles on GS published after 2015, and Supplementary File 3 lists the top 50 most-cited articles on GS published after 2015 among the top 1,000 most-cited articles. The citation counts ranged from 24 to 323; the publication years ranged from 2015 to 2017. The top 50 most-cited articles were published in 19 different journals; Endoscopy published the largest share of articles (20%), followed by Gastrointestinal Endoscopy (18%) (Supplementary Table 3).

In the GS bibliometrics of the top 50 most-cited articles published after 2015, citations of PMC articles showed a significant correlation with those from GS ($r=0.96$, $P<0.001$). The result was consistent after controlling for publication year, region of ESD, and type of article (partial correlation coefficient=0.91, $P<0.001$). A Kruskal-Wallis test showed no significant difference ($P=0.45$) in citation counts according to the publication year.

Of the top 50 most-cited articles published after 2015, original research comprised 88%, review 6%, guidelines or consensus reports 6%, and systematic reviews/meta-analyses 10% (Supplementary File 3).

For the region of ESD in each study, stomach comprised 38%, esophagus 32%, colon 22%, all regions 6%, and duodenum 2%. A Cochran-Armitage test for trends showed no significant difference ($P=0.46$) in publication numbers on different regions of ESD according to the publication year.

4. Bibliometrics of AAS

Supplementary Table 4 lists the top 10 AAS articles, and Supplementary File 4 lists the top 50 AAS articles. The AAS for the top 50 most-mentioned articles in online media ranged from 6 to 21. The publication years ranged from 2006 to 2019. The citation counts of PMC articles for the top 50 most-cited AAS articles ranged from 0 to 55. The top 50 most-cited AAS articles were published in 15 different journals. Gastrointestinal Endoscopy published

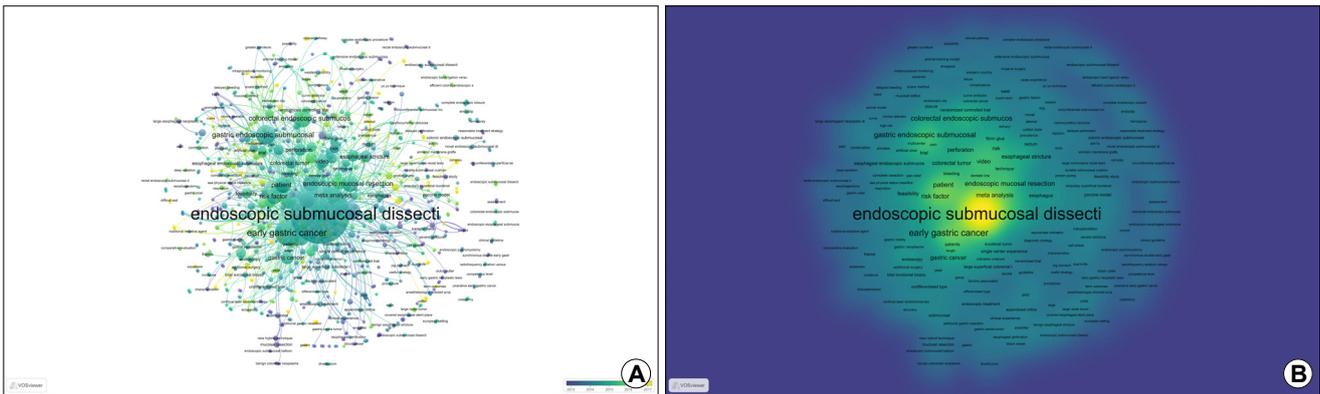


Fig. 1. Network plot of influential title words in endoscopic submucosal dissection research among the top 500 most cited articles of Web of Science Core Collection. (A) Overlay visualization. Each node is colored based on its score and the modularity clustering technique.¹⁴ (B) Density visualization of (A). The larger the number of items in the neighborhood of a node and the higher the weights of the neighboring items, the closer in color the point is to yellow. The smaller the number of items in the neighborhood of a node and the lower the weights of the neighboring items, the closer in color the point is to blue.¹⁴

the largest share of articles (42.6%), followed by VideoGIE (29.5%) (Supplementary Table 5).

In the top 50 most-cited AAS articles, citations of PMC articles showed no correlation with AAS ($r=-0.05$, $P=0.68$). The result was consistent after controlling for publication year, region of ESD, and type of article (partial correlation coefficient= -0.05 , $P=0.74$). A Kruskal-Wallis test showed no significant difference ($P=0.36$) in citation counts according to the publication year.

Of the top 50 AAS articles, original research comprised 60.7%, case reports 31.1%, review 6.6%, guidelines or consensus reports 1.6%, and systematic reviews/meta-analyses 6.6% (Supplementary File 4).

For the region of ESD in each study, colon comprised 42.6%, stomach 26.2%, esophagus 23%, duodenum 6.6%, and all regions 1.6%. A Cochran-Armitage test for trends showed no significant difference ($P=0.38$) in publication numbers on different regions of ESD from AAS bibliometrics according to the publication year.

5. Network-analysis for the most influential words in titles, abstracts, and of both titles and abstracts among the top 500 most-cited articles in WoSCC

Among the 1,040 words in the titles of the most-cited articles, Supplementary Table 6 lists the words with high

relevance-score. Words or terms with a high relevance-score included ‘colorectal ESD/EMR,’ ‘gastric ESD,’ ‘submucosal tunnel dissection,’ ‘guideline,’ ‘novel submucosal gel,’ and ‘esophageal squamous cell neoplasia.’¹³ Fig. 1A demonstrates the overlay visualization with no normalization layout. Fig. 1B demonstrates the density visualization of Fig. 1A.¹⁴ The following were influential title-words: ‘early gastric cancer (EGC),’ ‘meta-analysis,’ ‘risk factor,’ ‘esophageal stricture,’ ‘perforation,’ ‘bleeding,’ ‘colorectal tumor,’ ‘feasibility,’ ‘technique,’ ‘esophagus,’ ‘fibrin glue,’ ‘artificial ulcer,’ ‘porcine model,’ etc.

Among the 7,293 words in abstracts, Supplementary Table 7 lists the words with high relevance-score. Words or terms with a high relevance-score included ‘adhesive material,’ ‘cell sheet technology,’ ‘cultured autologous oral mucosal epithelial cell sheet,’ and ‘esophageal ulcer.’ Fig. 2A demonstrates the overlay visualization with association strength layout and Fig. 2B demonstrates the density visualization of Fig. 2A. The following were influential abstract-words: ‘*en bloc* resection,’ ‘recurrence,’ ‘second look endoscopy,’ ‘EGC,’ ‘endoscopic ultrasound,’ ‘neoplasia,’ ‘lymphovascular invasion,’ ‘additional surgical resection,’ ‘curative ESD,’ ‘ulcer healing,’ ‘rebamipide,’ ‘metastasis,’ ‘extragastric recurrence,’ ‘active bleeding,’ ‘proton pump inhibitor,’ ‘device,’ ‘CO₂ insufflation,’ ‘sedation,’ ‘speed,’ etc.

Among the 7,691 words in the titles and abstracts, Supplementary Table 8 lists the words with high rele-

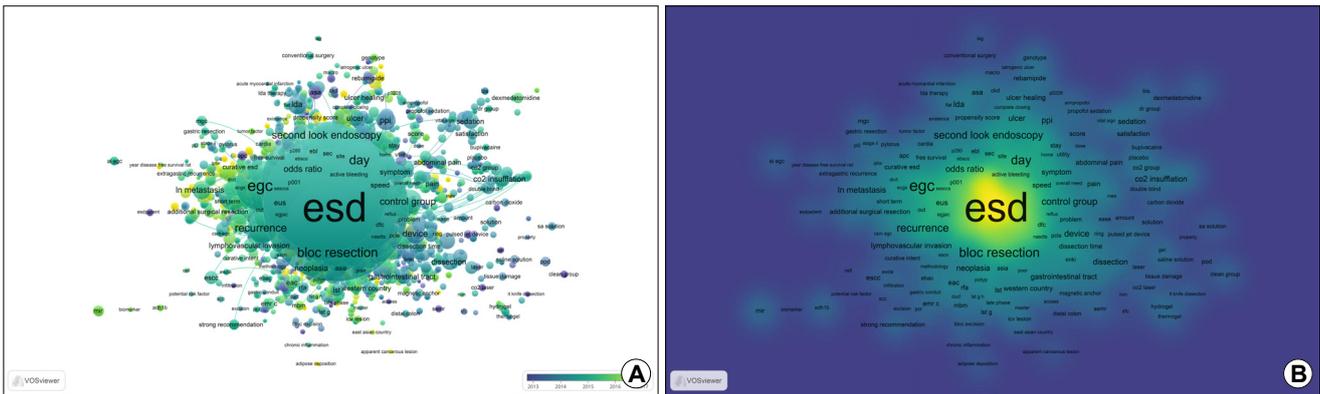


Fig. 2. Network plot of influential abstract words in endoscopic submucosal dissection (ESD) research among the top 500 most cited articles of Web of Science Core Collection. (A) Overlay visualization. (B) Density visualization of (A).

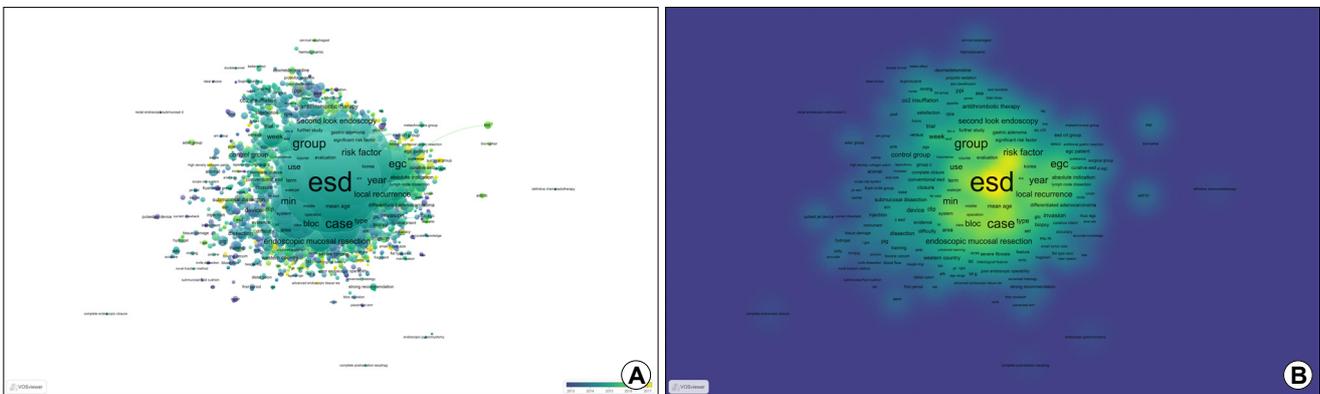


Fig. 3. Network plot of influential words in abstracts and titles of endoscopic submucosal dissection (ESD) research among the top 500 most cited articles of Web of Science Core Collection. (A) Overlay visualization. (B) Density visualization of (A).

vance-scores. Fig. 3A demonstrates the overlay visualization with linlog layout and Fig. 3B demonstrates the density visualization of Fig. 3A. The following were influential words and terms in the titles and abstracts: ‘perforation,’ ‘efficacy,’ ‘adverse event,’ ‘EGC,’ ‘curative resection,’ ‘bleeding,’ ‘esophageal stricture,’ ‘colorectal ESD,’ ‘colorectal tumor,’ ‘EMR,’ ‘tumor size,’ ‘gastric ESD,’ ‘bleeding,’ ‘risk factor,’ ‘second look endoscopy,’ ‘delayed bleeding,’ ‘post ESD bleeding,’ ‘elderly patients,’ ‘surgery,’ ‘technical difficulty,’ ‘adenoma,’ etc.

DISCUSSION

The citations of PMC articles among the top 50 WoSCC or GS articles showed a significant correlation with those

from each bibliometrics; however, AAS was not correlated. This was consistent with previous studies exploring the association between altmetric indicators and citation counts.^{15,16} A recent bibliometric analysis of neuro-intervention articles also suggested that AAS operates independently of citations and can be used as an alternative index for measuring an article’s impact.¹⁷ Considering that attention itself does not reflect the quality of research, AAS might not represent a qualified impact in specialized academic fields; however, information will no longer be inaccessible, and AAS, as a disseminative impact, might be a complementary indicator in the evaluation of the impact of a specific article.⁴

In terms of the topic of all four bibliometrics, guidelines or evidence-based technical reviews of each aca-

democratic society¹⁸⁻²¹ were common in the WoSCC or GS top 50 most-cited articles published after 2015, including recent citations. Studies with emerging issues, such as management of ESD-induced gastric perforation with an over-the-scope clip,²² ESD of early esophageal cancers²³ or superficial Barrett's neoplasia,^{24,25} ESD of EGC with undifferentiated-type histology,²⁶ therapeutic outcomes of POEM,²⁷ or natural orifice transluminal endoscopic surgery techniques, such as laparoscopic endoscopic cooperative surgery²⁸ were noted in the WoSCC or GS top 50 most-cited articles published after 2015, including recent citations. Large-scale cohort studies with over 1,000 cases that evaluated the efficacy and safety of ESD were also common in the WoSCC or GS top 50 bibliometrics.²⁹⁻³⁴

Upon increasing the analysis scheme to GS top 50 bibliometrics, many milestone papers and expert review articles that provided evidence for current practice standardization were included. A study on the introduction of POEM³⁵ and review publications that greatly affected the standardization of gastric ESD techniques, indications, and procedures were also included.^{36,37} In addition to gastric ESD, earlier studies that influenced the widespread use of ESD in the esophagus or colorectal area were included.^{38,39}

The composition of the top 10 most-cited AAS articles were slightly different from other bibliometrics. Additional validation of topics that may already be considered as having sufficient evidence were noted, such as a comparison of long-term outcomes of gastric ESD with surgery for EGCs that fulfilled the expanded indication,⁴⁰ or therapeutic outcomes of ESD of differentiated EGCs⁴¹ or colorectal tumors⁴² in Western countries. Studies that compared EMR with ESD for the treatment of superficial colorectal neoplasia⁴³⁻⁴⁵ received attention from various audiences. Studies about the development and validation of novel ESD techniques, such as endoscopic mucosa-sparing lateral dissection for the treatment of gastric subepithelial tumours or ESD for subepithelial tumours of the colon and rectum also received attention.^{46,47} Studies on emerging issues, such as the Western ESD trial on superficial Barrett's neoplasia⁴⁸ or the transplantation of autologous esophageal mucosa to prevent stricture after circumferential ESD of esophagus⁴⁹ were included. Upon increasing the analysis scheme to the top 50 most-cited AAS articles, most of the articles were video cases published

in VideoGIE.

In terms of the subject categories of published journals, 'Gastroenterology and Hepatology' (especially, endoscopy-related journals such as Gastrointestinal Endoscopy, Endoscopy, Digestive Endoscopy, Surgical Endoscopy and Other Interventional Techniques) was prevalent in all of the bibliometrics. However, other categories such as 'Surgery,' 'Oncology,' or 'Medicine, General, and Internal' were also prevalent, indicating that ESD research is not confined to one specialized academic field and journals with wider readerships are also eligible to publish research on ESD.

Original research was common in all of the top 50 bibliometrics (60.7~90%); however, video cases were also prevalent (31.1%) in top 50 AAS bibliometrics. Guidelines/consensus reports (1.6~6%) and systematic reviews/meta-analyses (4~10%) were prevalent and in the upper ranks of all bibliometrics, likely due to the consolidated and quantitative review of the large, complex, and sometimes conflicting field of articles in this era of overflowing publications.

For the region of ESD in each set of bibliometrics, stomach comprised 50% in GS bibliometrics (esophagus: 24%, colon: 16%); however, the proportion of colon and esophagus was increased in the bibliometrics of WoSCC (stomach: 32%, colon: 30%, esophagus: 20%) and GS published after 2015 (stomach: 38%, esophagus: 32%, colon: 22%), while the proportion of colon was most prevalent in the AAS bibliometrics (colon: 42.6%, stomach: 26.2%, esophagus: 23%).

A network-analysis of influential words in the titles or abstracts among the top 500 most-cited articles on WoSCC showed the recent interest of researchers relevant to ESD research. Words and terms with high relevance-scores were 'submucosal tunnel dissection,' 'guideline,' 'novel submucosal gel,' 'adhesive material,' 'cell sheet,' 'esophageal ulcer,' 'hemostatic spray,' and 'complete endoscopic closure,' and the following words and terms were influential: 'meta-analysis,' 'esophageal stricture,' 'perforation,' 'bleeding,' 'fibrin glue,' 'artificial ulcer,' 'porcine model,' 'esophageal squamous cell neoplasia,' excluding 'ESD.'

To the best of our knowledge, this is the first study using bibliometric analysis relevant to ESD research. We adopted

various bibliometric sources with in-depth analyses of citation counts, journals, publication years, and words in titles and abstracts. Despite its strengths, this study has limitations. First, only the 'number of citations' was adopted as a bibliometric index, excluding various other indices (such as article influence score, cited half-life or immediacy index, etc.). Previous studies exploring the impact of each bibliometric index suggested the significance and importance of specific bibliometric indices representing influence in each academic field.^{50,51} However, there has been no study stated above in the field of gastroenterology and we could adopt only 'number of citations' as a bibliometric index. Another limitation was that the number of top 50 most-cited articles might be insufficient in determining the most influential articles on ESD research. Visualization of network-analysis to determine the most influential title-words was impossible among the top 50 most-cited articles and this scheme should be increased to the top 500 most-cited articles.

In conclusion, this study can help researchers identify the most influential articles on ESD and provide insight into the most noteworthy scientific trends and to visualize future research needs of the topic.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Supplementary Table 1. Journals with Two or More of the Top 50 Most-cited Articles of Google Scholar Bibliometrics in Endoscopic Submucosal Dissection Research

Rank	Journal	Number of published articles in each journal among the top-50 cited articles	Journal impact factor based on JCR 2017	Eigenfactor™ score	Category by JCR
1	Gastrointestinal Endoscopy	17	7.204	0.034	Gastroenterology & hepatology
2	Endoscopy	11	6.629	0.018	Gastroenterology & hepatology/surgery
3	Surgical Endoscopy and Other Interventional Techniques	4	3.117	0.042	Surgery
4	Clinical Gastroenterology and Hepatology	3	7.683	0.038	Gastroenterology & hepatology
4	Gastric Cancer	3	5.045	0.007	Gastroenterology & hepatology/oncology
4	Gut	3	17.016	0.065	Gastroenterology & hepatology
7	Digestive Endoscopy	2	3.375	0.005	Gastroenterology & hepatology/surgery
7	Gastroenterology	2	20.773	0.132	Gastroenterology & hepatology
7	Journal of Gastroenterology	2	5.561	0.013	Gastroenterology & hepatology

JCR, journal citation reports.

Supplementary Table 2. The Top 50 Most-cited Articles of Google Scholar Bibliometrics in Endoscopic Submucosal Dissection Research Published after 2015 among the Top 1,000 Most-cited Articles (2015-2017)

Rank	First author	Journal	Title	Citation counts (GS)	Citation counts (PMC)	Stomach vs. colon vs. esophagus vs. duodenum	Type of article
1	Pimentel-Nunes P	Endoscopy 2015;47:829-84	Endoscopic submucosal dissection: European Society of Gastrointestinal Endoscopy (ESGE) guideline	323	78	All	Guideline/consensus report
2	Tanaka S	Dig Endosc 2015;27:417-434	JGES guidelines for colorectal endoscopic submucosal dissection/endoscopic mucosal resection	198	48	Colon	Guideline/consensus report
3	Ono H	Dig Endosc 2016;28:3-15	Guidelines for endoscopic submucosal dissection and endoscopic mucosal resection for early gastric cancer	159	30	Stomach	Guideline/consensus report
4	Fujiya M	Gastrointest Endosc 2015;81:583-595	Efficacy and adverse events of EMR and endoscopic submucosal dissection for the treatment of colon neoplasms: a meta-analysis of studies comparing EMR and endoscopic submucosal dissection	112	22	Colon	Original research (systematic review/meta-analysis)
5	Probst A	Endoscopy 2015;47:113-121	Early esophageal cancer in Europe: endoscopic treatment by endoscopic submucosal dissection	103	30	Esophagus	Original research
6	Familiari P	Ann Surg 2016;263:82-87	Peroral endoscopic myotomy for esophageal achalasia: outcomes of the first 100 patients with short-term follow-up	99	12	Esophagus	Original research
7	Terheggen G	Gut 2017;66:783-793	A randomised trial of endoscopic submucosal dissection versus endoscopic mucosal resection for early Barrett's neoplasia	90	12	Esophagus	Original research
8	ASGE Technology Committee; Maple JT	Gastrointest Endosc 2015;81:1311-1325	Endoscopic submucosal dissection	83	18	All	Review
8	Chevaux JB	Endoscopy 2015;47:103-112	Clinical outcome in patients treated with endoscopic submucosal dissection for superficial Barrett's neoplasia	83	24	Esophagus	Original research
10	Hiki N	Dig Endosc 2015;27:197-204	Laparoscopic endoscopic cooperative surgery	66	20	Stomach	Review

PMC, PubMed Central; JGES, Japan Gastroenterological Endoscopy Society; EMR, endoscopic mucosal resection.

Supplementary Table 3. Journals of the Top 50 Most-cited Articles of Google Scholar Bibliometrics in Endoscopic Submucosal Dissection Research Published after 2015 among the Top 1,000 Most-cited Articles

Rank	Journal	Number of published articles in each journal among the top-50 cited articles	Journal impact factor based on JCR 2017	Eigenfactor™ score	Category by JCR
1	Endoscopy	10	6.629	0.018	Gastroenterology & hepatology/surgery
2	Gastrointestinal Endoscopy	9	7.204	0.034	Gastroenterology & hepatology
3	Digestive Endoscopy	5	3.375	0.005	Gastroenterology & hepatology/surgery
4	Gastric Cancer	4	5.045	0.007	Gastroenterology & hepatology/oncology
4	Surgical Endoscopy and Other Interventional Techniques	4	3.117	0.042	Surgery
6	American Journal of Gastroenterology	2	10.231	0.056	Gastroenterology & hepatology
6	Digestion	2	2.037	0.003	Gastroenterology & hepatology
6	Endoscopy International Open	2	Not available	Not available	Not available
6	Gut	2	17.016	0.065	Gastroenterology & hepatology

JCR, journal citation reports.

Supplementary Table 4. The Top 10 AAS Articles in Endoscopic Submucosal Dissection Research (2006-2019)

Rank	First author	Journal	Title	AAS	Citation counts (PMC)	Stomach vs. colon vs. esophagus vs. duodenum	Type of article
1	Hahn KY	Surg Endosc 2018;32:73-86	Comparative study between endoscopic submucosal dissection and surgery in patients with early gastric cancer	21	0	Stomach	Original research
2	Fuccio L	Gut 2018;67:1464-1474	Why attempt en bloc resection of non-pedunculated colorectal adenomas? A systematic review of the prevalence of superficial submucosal invasive cancer after endoscopic submucosal dissection	20	3	Colon	Original research (systematic review/meta-analysis)
3	Li Y	Endoscopy 2018;50:886-890	Endoscopic mucosa-sparing lateral dissection for treatment of gastric submucosal tumors: a prospective cohort study	18	0	Stomach	Original research
4	Backes Y	BMC Gastroenterol 2016;16:56	Endoscopic mucosal resection (EMR) versus endoscopic submucosal dissection (ESD) for resection of large distal non-pedunculated colorectal adenomas (MATILDA-trial): rationale and design of a multicenter randomized clinical trial	15	7	Colon	Original research
4	Subramaniam S	Gastrointest Endosc 2017;86:608-618	Complex early Barrett's neoplasia at 3 Western centers: European Barrett's Endoscopic Submucosal Dissection Trial (E-BEST)	15	3	Esophagus	Original research
6	Qi ZP	Gastrointest Endosc 2018;87:540-548.e1	Efficacy and safety of endoscopic submucosal dissection for submucosal tumors of the colon and rectum	13	0	Colon	Original research
6	Kinoshita S	Gastrointest Endosc 2018;87:1079-1084	The role of colorectal endoscopic submucosal dissection in patients with ulcerative colitis	13	1	Colon	Original research
6	Emura F	Gastrointest Endosc 2015;82:804-811	Therapeutic outcomes of endoscopic submucosal dissection of differentiated early gastric cancer in a Western endoscopy setting (with video)	13	6	Stomach	Original research
9	Milano RV	Surg Endosc 2018;32:2328-2339	Resection outcomes and recurrence rates of endoscopic submucosal dissection (ESD) and hybrid ESD for colorectal tumors in a single Italian center	12	0	Colon	Original research
10	Liao Z	Gastrointest Endosc 2018;88:543-546	Transplantation of autologous esophageal mucosa to prevent stricture after circumferential endoscopic submucosal dissection of early esophageal cancer (with video)	11	0	Esophagus	Original research
10	Saunders BP	Nat Rev Gastroenterol Hepatol 2016;13:486-496	Endoscopic mucosal resection and endoscopic submucosal dissection of large colonic polyps	11	4	Colon	Review

AAS, Altmetric Attention Score; PMC, PubMed Central.

Supplementary Table 5. Journals with Two or More of the Top 50 AAS Articles in Endoscopic Submucosal Dissection Research

Rank	Journal	Number of published articles in each journal among the top-50 AAS articles	Journal impact factor based on JCR 2017	Eigenfactor™ score	Category by JCR
1	Gastrointestinal Endoscopy	26	7.204	0.034	Gastroenterology & hepatology
2	VideoGIE	18	Not available	Not available	Not available
3	Surgical Endoscopy and Other Interventional Techniques	4	3.117	0.042	Surgery
4	Medicine	2	2.028	0.008	Medicine, general & internal

AAS, Altmetric Attention Score; JCR, journal citation reports.

Supplementary Table 6. Influential Words in Title among the Top 500 Most-cited Articles in Web of Science Core Collection

Term	Relevance-score
Colorectal ESD EMR	3.89
Gastric ESD	3.89
STD	3.89
Guideline	3.89
Novel submucosal gel	3.89
Radiofrequency ablation	3.89
Simultaneous ESD	3.89
Synchronous double EGCs	3.89
Large early esophageal squamous cell neoplasia	3.89
Ulcerative EGC	3.89
Accurate diagnosis	3.16
Assessment	3.16
Circumferential superficial esophageal neoplasm	3.16
Colectomy	3.16
Competence level	3.16
Double tunnel	3.16
Endoscopic band ligation	3.16
Esophageal circumferential <i>en bloc</i> ESD	3.16
Giant polyp	3.16
Hemospray	3.16
Injectable hydrogel	3.16
Laparoscopic resection	3.16
Multifocal bleeding	3.16
Rectal ESD	3.16
Retraction problem	3.16
Short term outcomes	3.16
New technique	3.16
Perioperative advantage	3.16
Safe	3.16
Small gastric stromal tumor	3.16
Trainee	3.16
Learning curve	3.16
Ultra-low rectal ESD	3.16

VOSviewer calculates a relevance-score for each noun phrase. Noun phrases have a low relevance-score if their co-occurrences with other noun phrases follow a relatively random pattern; alternatively, they have high relevance-scores if they co-occur mainly with a limited set of other noun phrases. Noun phrases with low relevance-scores tend to be quite general, while noun phrases with high relevance-scores typically have more specific meanings.¹³

ESD, endoscopic submucosal dissection; EMR, endoscopic mucosal resection; STD, submucosal tunnel dissection; EGC, early gastric cancer.

Supplementary Table 7. Influential Words in Abstract among the Top 500 Most-cited Articles in Web of Science Core Collection

Term	Relevance-score
Adhesive material	2.88
Advanced endoscopic treatment	2.88
Cell sheet technology	2.88
Cultured autologous oral mucosal epithelial cell sheet	2.88
Endoscopic transplantation	2.88
Epithelialization	2.88
Esophageal ulcer	2.88
Key technology	2.88
Oral mucosal tissue	2.88
Regenerative procedure	2.88
Wound site	2.88
Protein expression level	2.88
Direct gene expression level	2.84
Luciferase assay	2.84
Molecular mechanism	2.84
mRNA	2.84
Pathway	2.84
Biomarker	2.84
Real time PCR	2.84
Recurrence free rate	2.84
Seed sequence	2.84
3'-UTR	2.84
Target gene	2.84
Viability	2.84
Western blot analysis	2.84

PCR, polymerase chain reaction; UTR, untranslated region.

Supplementary Table 8. Influential Words in Title and Abstract among the Top 500 Most-cited Articles in Web of Science Core Collection

Term	Relevance-score
Gastric ESD	13.85
Novel submucosal gel	13.85
Hemospray	12.20
Multifocal bleeding	12.20
Ultra-low rectal ESD	12.20
Seed sequence	11.50
Guideline	11.50
Complete endoscopic closure	7.53
Endoloop	7.53
Large gastric defect	7.53
Esophagus localized recurrence	7.51
Definitive chemoradiotherapy	7.51
Esophageal squamous cell cancer	7.51
Circumferential superficial esophageal neoplasm	6.97
Double tunnel	6.97
Recanalization	6.67
Complete postradiation esophageal obstruction	6.67
Gastroparesis	6.46
Surgical vagal lesion	6.46
Endoscopic pyloromyotomy	6.46
Gastric STD	6.46
Rectal ESD	5.68
Retraction problem	5.68
Novel traction method	3.99
Nylon string	3.99
Steroid gel application	3.81
Post ESD ulcer	3.64
Scope clip system	3.64
Endoscopic vessel sealing	2.94
Novel endoscopic precoagulation technique	2.94

ESD, endoscopic submucosal dissection; STD, submucosal tunnel dissection.