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Scientific Publications on Thyroid Ultrasound between 2001 and 2020: Differences in Research Characteristics by Disciplines

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Objective: To analyze the characteristics and trends of scientific publications on thyroid ultrasound (US) from 2001 to 2020, specifically examining the differences among disciplines.

Materials and Methods: The MEDLINE database was searched for scientific articles on thyroid US published between 2001 and 2020 using the PubMed online service. The evaluated parameters included year of publication, type of document, topic, funding, first author's specialty, journal name, subject category, impact factor, and quartile ranking of the publishing journal, country, and language. Relationships between the first author's specialty (radiology, internal medicine, surgery, otorhinolaryngology, and miscellaneous) and other parameters were analyzed.

Results: A total of 2917 thyroid US publications were published between 2001 and 2020, which followed an exponential growth pattern, with an annual growth rate of 11.6%. Radiology produced the most publications (n = 1290, 44.2%), followed by internal medicine (n = 716, 24.5%), surgery (n = 409, 14.0%), and otorhinolaryngology (n = 171, 5.9%). Otorhinolaryngology and internal medicine published significantly more case reports than radiology ($p < 0.001$, each). Radiology published a significantly higher proportion of publications on imaging diagnosis ($p < 0.001$ for all) and a significantly lower proportion of publications on biopsy ($p < 0.001$ for all) than the other disciplines. Publications produced by radiology authors were less frequently published in Q1 journals than those from other disciplines ($p < 0.005$ for internal medicine and miscellaneous disciplines and < 0.01 for surgery and otorhinolaryngology). China contributed the greatest number of publications (n = 622, 21.3%), followed by South Korea (n = 478, 16.4%) and the United States (n = 468, 16.0%).

Conclusion: Radiology produced the most publications for thyroid US than any other discipline. Radiology authors published more notably on imaging diagnosis compared to other topics and in journals with lower impact factors compared to authors in other disciplines.

Keywords: *Thyroid; Ultrasound; Bibliometric analysis; Publications; Research*

INTRODUCTION

Ultrasound (US) was developed as a military tool during World War II [1]. In 1947, Dussik et al. [2] first applied US as a diagnostic method in human subjects. The first reference to thyroid US examination appeared in 1965 in an article by Yamakawa and Naito [3] who described a method for calculating the size of the thyroid gland. US is easily accessible, cost-effective, noninvasive, and does not involve ionizing radiation. With all these advantages, as well as the superficial location of the thyroid gland, US has not only become an increasingly important tool in the diagnostic evaluation of thyroid disease but also plays an essential role in the management decision before and after biopsy and guidance for non-surgical interventional treatment in nodular thyroid disease.

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Bibliometric analysis is a quantitative method for evaluating scientific productions of different authors, departments, countries, journals, and publications related to a specific topic [4]. Many investigators from various disciplines have published articles on thyroid US, reflecting the broad application of this imaging technique in thyroid disorders. To our knowledge, there have been no bibliometric analyses of the trends and characteristics of research in this field.

The purpose of this study was to analyze the characteristics and trends of all scientific publications that focused on thyroid US from 2001 to 2020, with special attention to differences among different disciplines.

MATERIALS AND METHODS

This study was a retrospective bibliometric analysis of a publicly available database and was exempt from Institutional Review Board approval.

Search Strategy

The National Library of Medicine (NLM) MEDLINE database was searched using the PubMed search platform (http://www.ncbi.nlm.nih.gov/pubmed/) on May 7, 2021 to identify all scientific publications published between 2001 and 2020, primarily focusing on thyroid US. The search strategy was built by inputting the following terms: ((thyroid[Title]) AND (US[Title] OR ultrasound[Title] OR *sono*[Title] OR elastograph*[Title] OR Doppler[Title] OR "gray scale"[Title] OR "grey scale"[Title] OR aspiration[Title] OR ablation[Title] OR TI-RADS[Title] OR biopsy[Title] OR HIFU[Title] OR RFA[Title] OR sclerotherapy[Title])) AND (("2001/01/01"[Date - Publication]: "2020/12/31"[Date - Publication])). The search resulted in 4553 publications.

First, articles that were e-published ahead of print but not yet included in a finalized printed issue from 2001 to 2020 were excluded (n = 70). We also excluded articles with a homograph in the title (n = 30; e.g., the US as in the United States). We restricted our analysis to studies directly related to thyroid US or thyroid US-guided procedures. The articles mainly focused on subjects other than thyroid US or thyroid US-guided procedures (n = 1536), such as cytopathology (n = 683), medical treatment (n = 510), thyroid surgery (n = 66), computer science (n = 20), genetics (n = 19), basic science (n = 10), epidemiology (n = 4), and others (n = 224). The remaining 2917 articles were included in this study (Fig. 1).

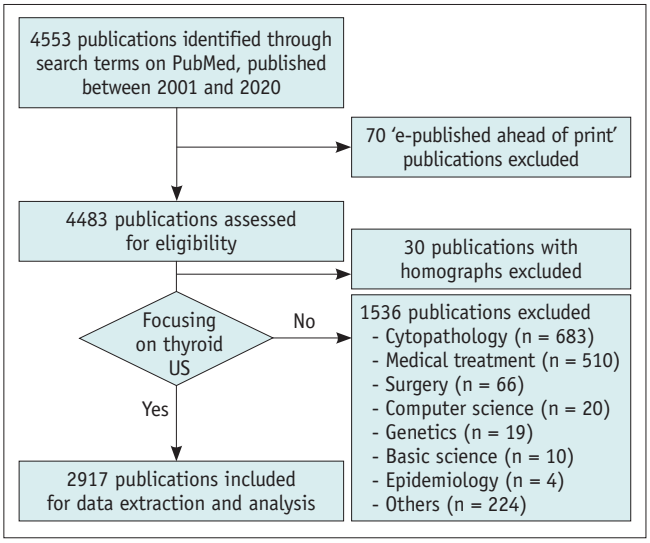

Fig. 1. Flow chart of publications evaluated for inclusion in bibliometric analysis. US = ultrasound

Parameters Evaluated

For the analysis, the following information was obtained from each article: 1) year of publication, 2) type of document (original article, review, case report, or miscellaneous [pictorial essay, editorial, letter, technical note, quiz, educational material, book review, commentary, and news]), 3) topic (imaging diagnosis, biopsy, and interventional treatment), 4) funding, 5) the first author's specialty (radiology, internal medicine, surgery, otorhinolaryngology, and miscellaneous specialties), 6) journal name, 7) subject category (radiology, internal medicine, surgery, otorhinolaryngology, and miscellaneous categories), impact factor (IF), and quartile ranking of the publishing journal, 8) country of origin, and 9) language of the article. We also evaluated the relationships between the first author's specialty and other evaluated parameters.

If information about the authors' department was not available or was ambiguous (such as thyroid center or thyroid research unit) from the MEDLINE database, we searched the Internet home page of the institute to obtain additional information. For the purpose of our research, the country of origin of the first author was considered the country of origin of the paper. According to the Journal Citation Reports (JCR; Clarivate Analytics), several journals are listed under more than one subject category, depending on the content of the journal. Journals that fell into more than one category were manually reviewed and assigned to only one category based on the title of the journal, the information contained in "Instructions to Authors," and the

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table of contents in a sample issue. The IF of each journal was determined using JCR Science Edition 2020. Journals were divided into four quartiles based on the journal IF: Q1, which is occupied by the top 25% of the journal list of subject categories, Q2 (25%–50% group), Q3 (50%–75% group), and Q4 (75%–100% group). Of note, some journals could not be found in the JCR Science Edition (n = 248), and some were not indexed in the Science Citation Expanded; these journals did not have associated IFs (n = 139). Therefore, articles from these journals were excluded from the IF analysis.

Two study investigators (author 1 and author 2) independently reviewed the titles and abstracts (and full text if required) of each article to identify eligible studies and extract data. Discrepancies were resolved by arbitration with a third investigator (author 3).

Analyses

The data were downloaded into a spreadsheet for analysis using Microsoft Office Excel 2016 (Microsoft Corp.). Relationships between the first author's departments (radiology, internal medicine, surgery, otorhinolaryngology, and miscellaneous) and the other evaluated parameters were assessed using chi-square and post hoc analysis, when appropriate. Regression analysis was used to explore the trends in the total number of thyroid US publications by country and topic. Otherwise, the present study adopted a descriptive research approach through bibliometric analysis.

Statistical analyses were performed using R version 4.0.3 (R Foundation for Statistical Computing), and a p value < 0.05 was considered statistically significant.

RESULTS

The total number of thyroid US publications showed exponential growth from 2001 to 2020, with an annual growth rate of 11.6%. Radiology produced the most thyroid US publications (n = 1290, 44.2%), followed by internal medicine (n = 716, 24.5%), surgery (n = 409, 14.0%), and otorhinolaryngology (n = 171, 5.9%).

The growth patterns in the number of publications were exponential in both the radiology and non-radiology disciplines, with annual growth rates of 13.6% and 10.1%, respectively. However, each of the four non-radiology disciplines showed a linear growth pattern in contrast to radiology. Although radiology produced the most thyroid US publications overall (44.2%) among the four disciplines, the proportion of articles published by non-radiology disciplines (55.8%) was higher (Fig. 2).

The most common document type was original articles (n = 2235, 76.6%), followed by reviews (n = 303, 10.4%) and case reports (n = 169, 5.8%). Radiology published the most publications in the original articles (46.2%, 1033/2235) and reviews (40.9%, 124/303). Otorhinolaryngology and internal medicine published significantly higher proportions of case reports than did radiology (p value < 0.001, each).

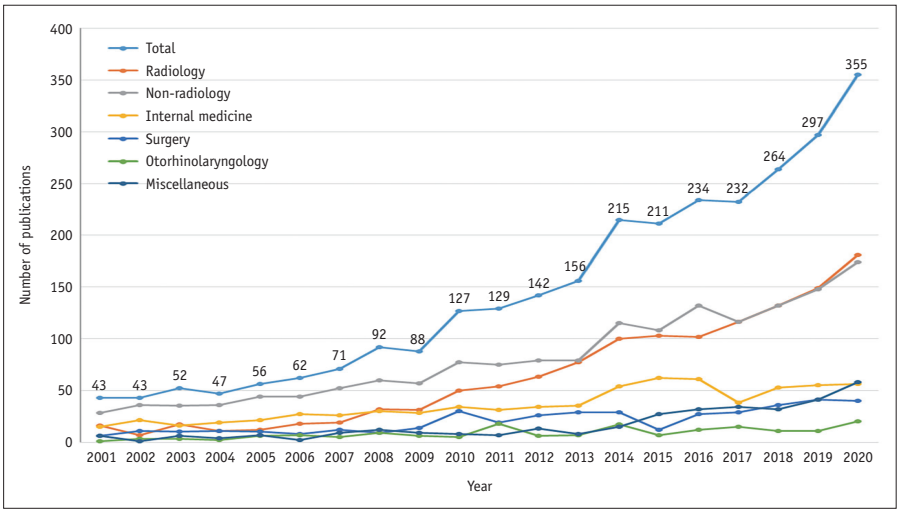

Fig. 2. Graphs showing the annual growth of the number of scientific publications on thyroid ultrasound from 2001 to 2020 by discipline. Total: exponential adjustment ($y = 38.3130281914^x$, $R^2 = 0.981$). Radiology: exponential adjustment ($y = 9.14959851333^x$, $R^2 = 0.934$). Non-radiology: exponential adjustment ($y = 29.6626891951^x$, $R^2 = 0.977$). Internal medicine: linear adjustment ($y = 2.3684x + 10.9316$, $R^2 = 0.818$). Surgery: linear adjustment ($y = 1.6895x + 2.7105$, $R^2 = 0.757$). Otorhinolaryngology: linear adjustment ($y = 0.7060x + 1.1368$, $R^2 = 0.581$). Miscellaneous: linear adjustment ($y = 2.2414x - 6.9842$, $R^2 = 0.739$).

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Radiology published the most publications on imaging diagnosis (55.0%, 817/1485) and interventional treatment (46.6%, 200/429) among the disciplines. However, internal medicine produced the most publications on the topic of biopsy (31.8%, 319/1003). Of the 2917 included publications, 579 (19.8%) received funding (Table 1). Regarding the topic, all three of the radiology, non-radiology, and overall disciplines showed exponential growth in the number of publications except biopsy of the radiology discipline (Fig. 3).

The journal that published the most thyroid US publications was *Thyroid* (n = 166), followed by *the Journal of Ultrasound in Medicine* (n = 118), and *the American Journal of Roentgenology* (n = 79) (Table 2). Four major disciplines published the most (37.9%–70.1%) of their articles in their own subject category journals. The overall mean IF of journals was 3.752. The highest mean journal IF was reached by miscellaneous journals (4.288), followed by internal medicine journals (4.013). Publications produced by radiology authors were less frequently published in Q1 journals than those from other disciplines (p value < 0.005 for internal medicine and miscellaneous disciplines and < 0.01 for surgery and otorhinolaryngology) (Table 3).

China contributed the greatest number of publications on thyroid US (n = 622, 21.3%), followed by South Korea (n = 478, 16.4%) and the United States (n = 468, 16.0%). China was the only country that showed exponential growth in radiology, non-radiology, and the overall discipline (Fig. 4).

In the top three most productive countries, the radiology discipline produced the most publications in China (67.0%), South Korea (84.1%), and the United States (31.0%) (Table 4). Although the overall number of published articles was similar in South Korea and the United States (478 vs. 468), the majority of articles were published by non-radiologists in the United States (69.0%, 323/468).

Most publications were written in English (n = 2755, 94.4%).

DISCUSSION

In this bibliometric analysis, we evaluated the characteristics of scientific publications related to thyroid US from 2001 to 2020, which provides insights into the characteristics of research in this field.

In our study, the total number of publications on thyroid US showed an exponential annual growth rate of 11.6%, which was higher than that of US publications identified in

Table 1. Characteristics of Scientific Publications on Thyroid Ultrasound between 2001 and 2020

	Department of the First Author					
	Radiology (n = 1290)	Internal Medicine (n = 716)	Surgery (n = 409)	Otorhinolaryngology (n = 171)	Miscellaneous (n = 331)	Total (n = 2917)
Document type						
Original article	1033 (80.1)	509 (71.1)	313 (76.5)	129 (75.4)	251 (75.8)	2235 (76.6)
Review	124 (9.6)	85 (11.9)	43 (10.5)	19 (11.1)	32 (9.7)	303 (10.4)
Case report	55 (4.3)	59 (8.2)*‖	20 (4.9)	22 (12.9)*‡‖	13 (3.9)	169 (5.8)
Miscellaneous	78 (6.0)	63 (8.8)	33 (8.1)	1 (0.6)	35 (10.6)	210 (7.2)
Topic						
Imaging diagnosis	817 (63.3)†‡§	299 (41.8)¶	119 (29.1)	50 (29.2)	200 (60.4)†‡§	1485 (50.9)†
Biopsy	273 (21.2)¶	319 (44.6)	224 (54.8)	94 (55.0)	93 (28.1)¶	1003 (34.4)
Interventional treatment	200 (15.5)	98 (13.7)	66 (16.1)	27 (15.8)	38 (11.5)	429 (14.7)
Declared funding						
Funded	275 (21.3)‡	135 (18.9)	59 (14.4)	23 (13.5)	87 (26.3)†‡§	579 (19.8)
Not funded	994 (77.1)	574 (80.2)	349 (85.3)	146 (85.4)	239 (72.2)	2302 (78.9)
Unknown	21 (1.6)	7 (1.0)	1 (0.2)	2 (1.2)	5 (1.5)	36 (1.2)

Numbers in parentheses are percentages. *Significantly different from value for Radiology, †Significantly different from values for Internal medicine, ‡Significantly different from values for Surgery, §Significantly different from values for Otorhinolaryngology, ‖Significantly different from value for Miscellaneous, ¶Significantly different from values for all other departments.

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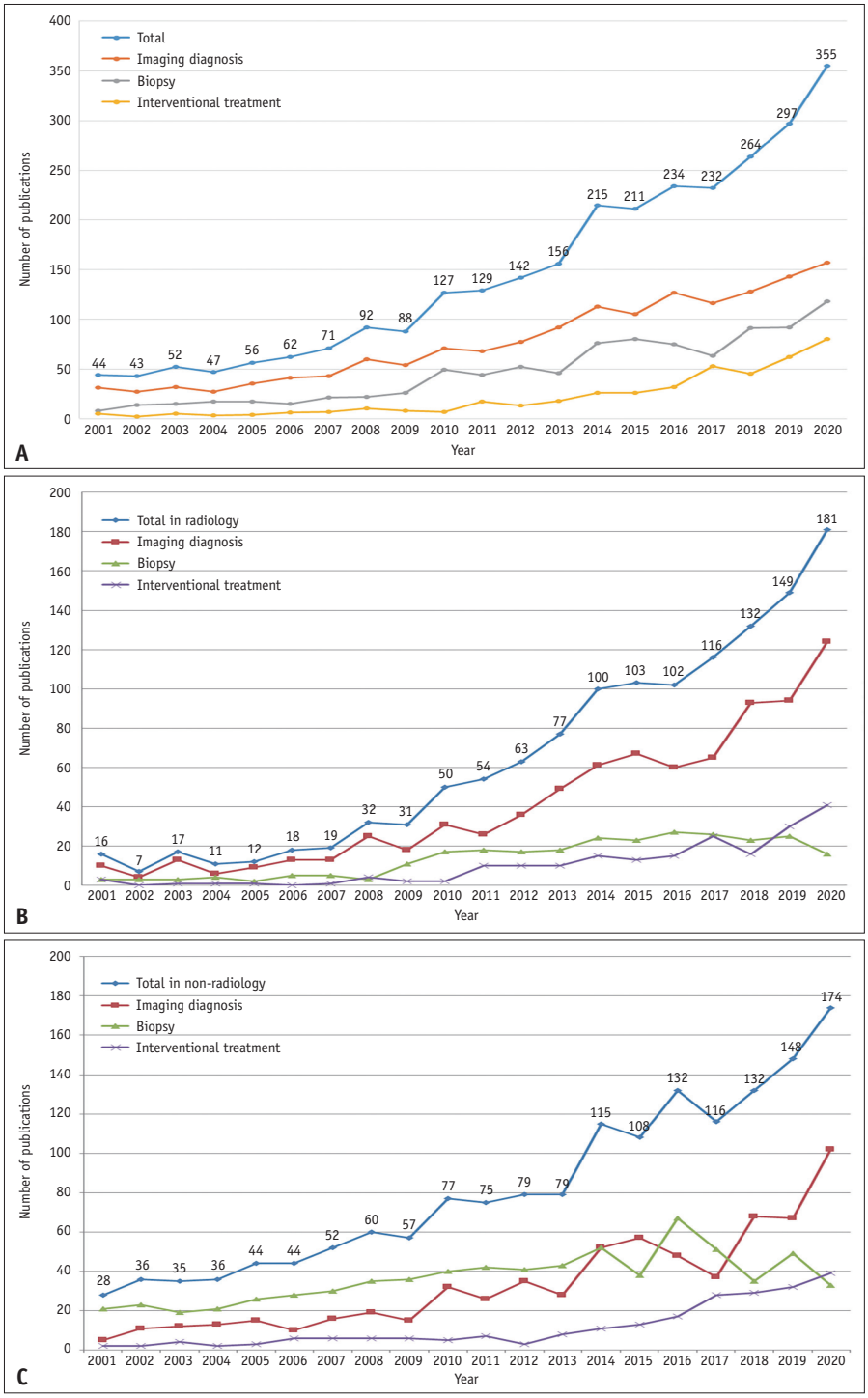

Fig. 3. Graphs showing the annual growth of the number of scientific publications on thyroid ultrasound from 2001 to 2020 by topic.

A. Overall. Total: exponential adjustment ($y = 38.3130281914^{x}$, $R^2 = 0.981$). Imaging diagnosis: exponential adjustment ($y = 25.8179503499^{x}$, $R^2 = 0.963$). Biopsy: exponential adjustment ($y = 10.4202392842^{x}$, $R^2 = 0.939$). Interventional treatment: exponential adjustment ($y = 2.44660169884^{x}$, $R^2 = 0.926$). **B.** In radiology discipline. Total in radiology: exponential adjustment ($y = 9.14959851333^{x}$, $R^2 = 0.934$). Imaging diagnosis: exponential adjustment ($y = 5.92972022457^{x}$, $R^2 = 0.9167$). Biopsy: linear adjustment ($y = 1.4068x - 1.1211$, $R^2 = 0.7881$). Interventional treatment: exponential adjustment ($y = 1.13254517507^{x} - 1$, $R^2 = 0.8203$). **C.** In non-radiology discipline. Total in non-radiology: exponential adjustment ($y = 29.6626891951^{x}$, $R^2 = 0.977$). Imaging diagnosis: exponential adjustment ($y = 7.59229358777^{x}$, $R^2 = 0.9007$). Biopsy: exponential adjustment ($y = 22.3385429956^{x}$, $R^2 = 0.6094$). Interventional treatment: exponential adjustment ($y = 2.56210706955^{x}$, $R^2 = 0.8423$).

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Table 2. Top 20 Journals with the Highest Number of Scientific Publications on Thyroid US between 2001 and 2020

Rank	Journal	Journal IF*	No. of US Articles
1	*Thyroid*	6.568	166
2	*Journal of Ultrasound in Medicine*	2.153	118
3	*American Journal of Roentgenology*	3.959	79
4	*Endocrine*	3.633	71
5	*Ultrasound in Medicine & Biology*	2.998	68
6	*Endocrine Practice*	3.443	58
7	*International Journal of Hyperthermia*	3.914	57
8	*The Journal of Clinical Endocrinology & Metabolism*	5.958	54
9	*European Radiology*	5.315	50
10	*Clinical Endocrinology*	3.478	47
11	*Radiology*	11.105	44
12	*Korean Journal of Radiology*	3.500	43
12	*Journal of Clinical Ultrasound*	0.910	43
14	*World Journal of Surgery*	3.352	40
15	*Head & Neck*	3.147	37
16	*Medicine (Baltimore)*	1.889	36
17	*Journal of Endocrinological Investigation*	4.256	34
17	*European Journal of Radiology*	3.528	34
19	*Surgery*	3.982	32
20	*Annals of Surgical Oncology*	5.344	30

*The IF of each journal was determined using the JCR Science Edition 2020. IF = impact factor, US = ultrasound

a previous bibliometric study comparing the same period overlapping in both studies [5]. Chen et al. [5] reported that the annual trend of all US publications showed a weak linear pattern between 2001 and 2006, with an annual growth rate of 2.4%, which was 7.6% during the same period in our study. This remarkably high growth rate of thyroid US publications seems to be related to the increasing clinical role of thyroid US in the management of nodular thyroid disease, which is closely related to "thyroid cancer" and "thyroid nodule," the topics showing an increasing trend between 2006 and 2015 [6]. Factors such as the increasing worldwide prevalence or detection of thyroid disease, growing interest in thyroid US research, and possibly the increasing use of thyroid US in multiple disciplines are also attributed to the increasing trend. The most active discipline was radiology, accounting for 44.2% of publications; however, this result also indicates that non-radiology disciplines produced slightly more publications than radiology disciplines.

Table 3. Subject and IF of Journals that Published Scientific Publications on Thyroid Ultrasound between 2001 and 2020

	Department of the First Author					
	Radiology (%)	Internal Medicine (%)	Surgery (%)	Otorhinolaryngology (%)	Miscellaneous (%)	Total (%)
Journal subject**						
Radiology	699 (54.2)¶	64 (8.9)	36 (8.8)	11 (6.4)	68 (20.5)¶	878 (30.1)
Internal medicine	329 (25.5)	502 (70.1)¶	140 (34.2)*	38 (22.2)‡	106 (32.0)	1115 (38.2)
Surgery	36 (2.8)	16 (2.2)	155 (37.9)¶	15 (8.8)¶	7 (2.1)	229 (7.9)
Otorhinolaryngology	27 (2.1)	8 (1.1)	11 (2.7)	81 (47.4)¶	8 (2.4)	135 (4.6)
Miscellaneous	100 (7.8)	77 (10.8)	35 (8.6)	9 (5.3)	91 (27.5)	312 (10.7)
IF††						
Mean journal IF ± standard deviation	3.587 ± 2.125	4.013 ± 3.112*	3.591 ± 2.940	3.318 ± 1.831	4.288 ± 5.916*‡§	3.752 ± 3.097
No. of publications in Q1 journals	239 (21.0)¶	197 (31.4)	116 (32.3)	53 (38.4)	95 (35.6)	700 (24.0)
No. of publications in Q2 journals	415 (36.4)†‡‖	105 (16.7)¶	97 (27.0)	42 (30.4)	64 (24.0)	723 (24.8)
No. of publications in Q3 journals	293 (25.7)	191 (30.5)	83 (23.1)	30 (21.7)	67 (25.1)	664 (22.8)
No. of publications in Q4 journals	192 (16.9)	134 (21.4)	63 (17.5)	13 (9.4)	41 (15.4)	443 (15.2)

Q1 is occupied by the top 25% of journals in the list, Q2 is occupied by journals in the 25% to 50% group, Q3 is occupied by journals in the 50% to 75% group, and Q4 is occupied by journals in the 75% to 100% group based on the journal IF. *Significantly different from value for Radiology, †Significantly different from values for Internal medicine, ‡Significantly different from values for Surgery, §Significantly different from values for Otorhinolaryngology, ‖Significantly different from value for Miscellaneous, ¶Significantly different from values for all other departments, **Percentages do not sum up to 100% because journals that are not indexed in Journal Citation Reports were not included, ††Percentages do not sum up to 100% because journals that are not SCIE-indexed were excluded. IF = impact factor

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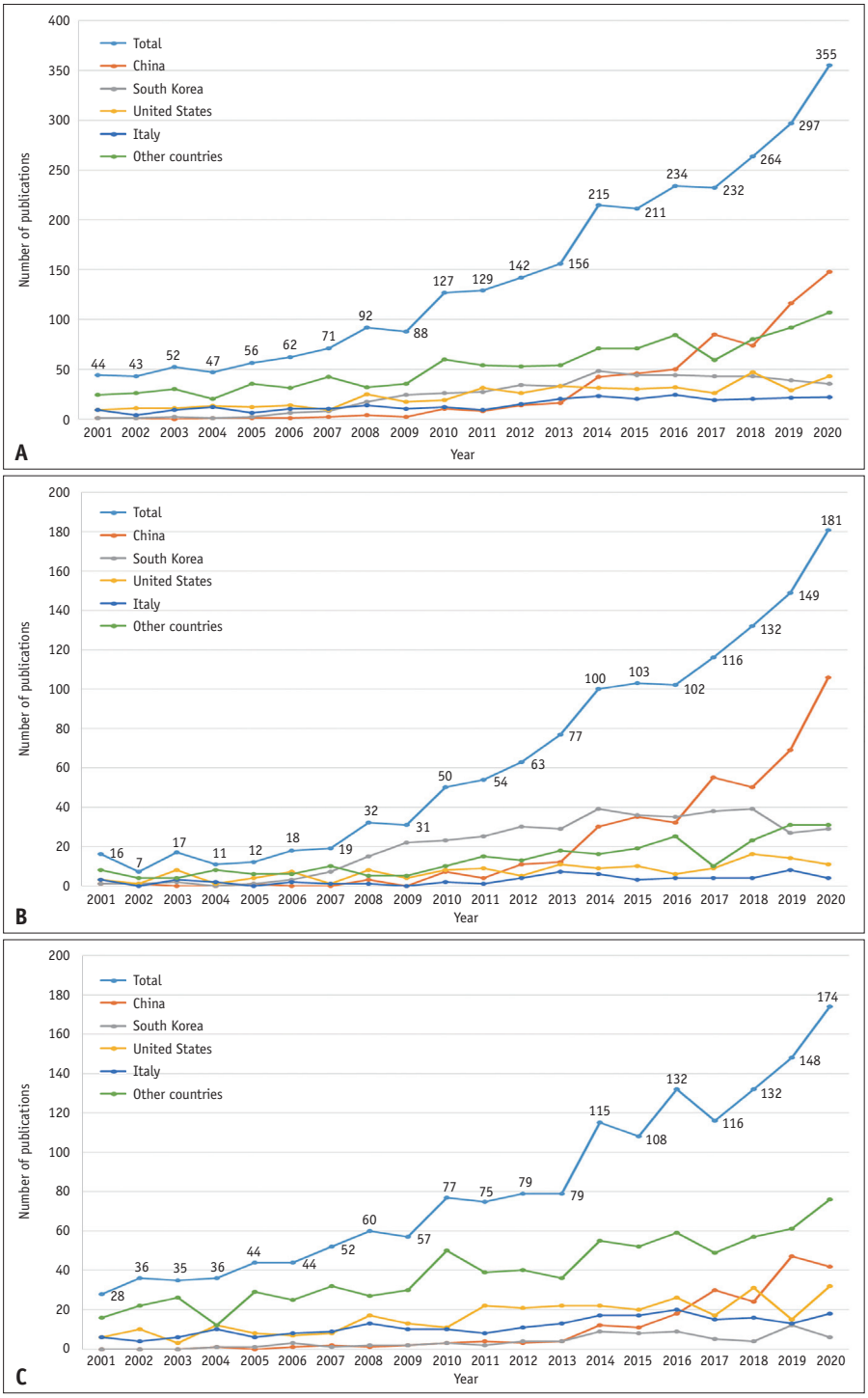

Fig. 4. Graphs showing the annual growth of the number of scientific publications on thyroid ultrasound from 2001 to 2020 by countries. **A.** Overall. Total: exponential adjustment ($y = 38.3130281914^x$, $R^2 = 0.981$). China: exponential adjustment ($y = 0.83210220762^x - 1$, $R^2 = 0.938$). South Korea: linear adjustment ($y = 2.743x - 4.900$, $R^2 = 0.852$). United States: exponential adjustment ($y = 9.67707803662^x$, $R^2 = 0.804$). Italy: linear adjustment ($y = 0.912x + 4.874$, $R^2 = 0.757$). Other countries: exponential adjustment ($y = 22.753523215^x$, $R^2 = 0.885$). **B.** In radiology discipline. Total in radiology: exponential adjustment ($y = 9.14959851333^x$, $R^2 = 0.934$). China: exponential adjustment ($y = 0.60571794483^x - 1$, $R^2 = 0.847$). South Korea: linear adjustment ($y = 2.27x - 3.69$, $R^2 = 0.81$). United States: linear adjustment ($y = 0.542x + 1.558$, $R^2 = 0.566$). Italy: linear adjustment ($y = 0.2444x + 0.3842$, $R^2 = 0.377$). Other countries: exponential adjustment ($y = 4.33967734119^x$, $R^2 = 0.725$). **C.** In non-radiology discipline. Total in non-radiology: exponential adjustment ($y = 29.6626891951^x$, $R^2 = 0.977$). China: exponential adjustment ($y = 0.66179462851^x - 1$, $R^2 = 0.937$). South Korea: exponential adjustment ($y = 1.1828183229^x - 1$, $R^2 = 0.805$). United States: linear adjustment ($y = 1.156x + 4.016$, $R^2 = 0.667$). Italy: exponential adjustment ($y = 5.73914359659^x$, $R^2 = 0.735$). Other countries: linear adjustment ($y = 2.667x + 11.647$, $R^2 = 0.85$).

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Table 4. Top 20 Countries that Contributed to Scientific Publications on Thyroid Ultrasound between 2001 and 2020

Rank	Country	Department of the First Author					
		Radiology	Internal Medicine	Surgery	Otorhinolaryngology	Miscellaneous	Total (%)
1	China	417	50	83	7	65	622 (21.3)
2	South Korea	402	35	16	15	10	478 (16.4)
3	United States	145	100	118	51	54	468 (16.0)
4	Italy	59	160	27	3	40	289 (9.9)
5	Turkey	58	45	31	5	6	145 (5.0)
6	Brazil	12	35	1	4	16	68 (2.3)
6	Germany	11	32	7	3	15	68 (2.3)
6	Japan	7	17	18	9	17	68 (2.3)
9	Poland	12	36	8	0	8	64 (2.2)
10	India	16	6	14	9	7	52 (1.8)
11	Canada	10	10	5	13	8	46 (1.6)
12	United Kingdom	14	7	4	10	9	44 (1.5)
13	Taiwan	8	20	6	3	6	43 (1.5)
14	France	18	7	1	6	7	39 (1.3)
14	Iran	10	8	4	3	14	39 (1.3)
16	Spain	7	23	6	0	2	38 (1.3)
17	Greece	4	14	4	1	8	31 (1.1)
18	Denmark	2	11	0	9	1	23 (0.8)
19	Russia	6	2	1	1	11	21 (0.7)
20	Singapore	10	3	5	0	2	20 (0.7)

Data dose not sum up to 100% because shares of other countries were not included.

One interesting finding of our study was that the United States was ranked third in thyroid US publications (16.0%). This relative contribution of the United States is much smaller than that reported by Lim et al. [7] (45.5%) covering 2001–2010. In Chen et al. [5] analysis of all US publications covering 1991–2006, the United States was the leader, followed by Germany, the United Kingdom, and France. In contrast, in our thyroid US study, the United States, Germany, the United Kingdom, and France ranked third, seventh, twelfth, and fourteenth, respectively. The exact cause of the low productivity of thyroid US articles in these countries is unclear and likely multifactorial. Two Asian countries, China and South Korea, accounted for 37.7% of the total number of publications on thyroid US. The cause of this high research productivity is also indefinite, but it can be hypothesized that an excessive number of thyroid US or US-guided biopsy and interventional treatments in these countries may be a key factor [8,9]. In particular, China was the leading country in thyroid US publications, and the only country that showed exponential growth in radiology, non-radiology, and overall disciplines. According to many bibliometric studies in various medical fields, China showed a significantly rapid growth in the annual number of articles compared to other countries during a similar period [10-12]. This may indicate that there is also an external factor in which the overall publication activity in China is growing sharply in relation to its socioeconomic factors. In addition, non-radiology published more articles than radiology in all countries, including the United States, except China and South Korea, which may suggest that research on thyroid US is led by non-radiology disciplines rather than radiology disciplines, except China and South Korea. Although the hidden cause of this phenomenon may be beyond the scope of this study, it probably depends on who performs the thyroid US—radiologist or non-radiology physicians, which differs by country [13,14].

Overall, original articles were the most common type of documents, accounting for 76.6% of the total publications. However, the percentage of original articles from the radiology department (80.1%) was higher than that from other disciplines, although the difference did not reach statistical significance. The higher proportion of original articles may suggest that the radiology discipline played the most important role in the dissemination of new scientific knowledge and concepts in thyroid US. Our results indicate that the topic of scientific articles also varies across disciplines. Radiology published a significantly higher

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proportion of diagnostic US articles than other disciplines, whereas internal medicine, surgery, and otorhinolaryngology published a significantly higher proportion of articles on US-guided biopsy than did radiology. Nevertheless, among the disciplines, the number of publications on biopsy from radiology is still the second highest (27.2%, 273/1003) after internal medicine (31.8%, 319/1003). US-guided biopsy is a field of strong competition among all disciplines. The importance of funding and its positive association with research productivity are well established [15]. Radiology has the highest funding rate (21.3%) among the four major disciplines. This funding rate was comparable to that reported in a previous study on general radiology (26.9%), which included only original articles from two high-impact radiology journals [7].

Four major disciplines published the most, but a small proportion of their articles were published in their own subject category journals (37.9%–70.1%). In particular, surgical researchers have published their articles almost equally in surgery and internal medicine journals. One of the current trends in scientific writing is publication across disciplines. Previous studies have reported the evolution of departmental affiliations of primary authors in surgery and radiology [16,17]. Internal medicine and miscellaneous authors have published their findings in journals with higher IFs. However, it cannot be concluded that the research of these groups was superior to that of other disciplines because there are limitations in comparing IFs across specialties. Moreover, the IF of journals in which articles are published does not necessarily reflect the quality of the articles [18]. A possible explanation is that these authors published a significantly higher proportion of articles in internal medicine journals, which had more readers, higher citation rates, and higher journal IFs. In addition, the lower proportion of articles produced by radiology authors in Q1 journals may reflect the fact that thyroid US is a minor subspecialty in the field of radiology in terms of academic impact.

Historically, thyroid US and US-guided procedures have been the domain of radiologists, as thyroid US is a core competency acquired during radiology training. In many countries, radiology board committees require residents to accomplish adequate training in thyroid US and US-guided biopsy for certification in diagnostic radiology [19-21]. However, there has been an increased utilization of thyroid US examinations performed by self-referring non-radiologist physicians in hospitals. At present, as patients with thyroid nodules are initially referred to internal medicine physicians (mainly endocrinologists and oncologists), surgeons, or otorhinolaryngologists, an increasing number of physicians from these disciplines perform thyroid US and US-guided procedures. However, it is unclear how many thyroid US- and US-guided procedures are currently performed in each discipline. In addition, image-guided interventional treatment of patients with thyroid nodular disease requires overall management of patients and close communication between operators and patients. Thus, non-radiology physicians may have a higher chance of using thyroid US for the clinical management of patients with nodular thyroid disease.

It seems that there has been a turf war regarding which of the four disciplines—radiology, internal medicine, surgery, and otorhinolaryngology—has the right to perform thyroid US and US-guided procedures. Expanding the influence of certain disciplines and monetary gains may be the major factors behind these conflicts. This current situation may result in a steady increase in the use of US for the thyroid gland and subsequent scientific publications in this field. There are two serious concerns regarding this issue. First, since thyroid cancer can metastasize to the cervical lymph nodes and spread directly to adjacent structures in the neck, the thyroid US operator should have the ability to assess not only the thyroid gland but also the surrounding structures. Therefore, non-radiology physicians should be systematically trained in specially designed programs. However, previous surveys have shown that the majority of endocrine surgeons and endocrinologists who performed thyroid US have not been provided with adequate US training or certification programs [22,23]. Second, self-referral in thyroid US- and US-guided procedures creates a problem for healthcare systems in that it leads to higher utilization of imaging studies and medical costs [24].

The bibliometric methodology used in this study has some limitations. First, the publication data used in this study were obtained from the NLM MEDLINE database via PubMed. However, this database mainly includes journals published in English, whereas regional journals in other languages are less likely to be found in PubMed. Nonetheless, any discrepancies or biases in the indexing patterns of PubMed could have influenced the results. Second, although efforts were made using all possible search terms to include most scientific articles mainly focused on thyroid US, some articles that did not include these terms in their titles may have been excluded. However, the goal of this study

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was not to capture every thyroid US article, but rather to examine a large representative sample to analyze the trends and characteristics of research within this field. Finally, the assignment of the clinical specialty and country was based on the affiliation of the first author, which may be potentially problematic in instances where articles involved collaborative efforts between multiple specialties. However, several previous studies [25,26] have shown that the first authors make the greatest contribution to the research and are deserving of credit.

In conclusion, although the radiology discipline produced the most publications, radiology led publications only in China and South Korea, and non-radiology led publications in the rest of the countries, including the United States. Radiology, internal medicine, surgery, and otorhinolaryngology make important contributions in this field, with radiology authors publishing more notably on imaging diagnosis compared to other topics and in journals with lower IFs compared to authors in other disciplines.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Dae Young Yoon. Data curation: Won Chul Shin, Chae Woon Lee. Formal analysis: Chae Woon Lee, Dae Young Yoon. Methodology: Dae Young Yoon. Resources: Dae Young Yoon. Supervision: Dae Young Yoon. Writing—original draft: Won Chul Shin, Chae Woon Lee. Writing—review & editing: Jiyeon Ha, Kyoung Ja Lim, Young Lan Seo, Eun Joo Yun, Dae Young Yoon.

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