



ORIGINAL ARTICLE / *Professional information*

Academic productivity of French radiology residents: Where do we stand?



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KEYWORDS

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Abstract

Rationale and objectives: Although medical research by French radiology residents is encouraged, their publication productivity remains unknown. Thus, we aimed to assess and analyze the publication rate of medical theses and the overall academic productivity of radiology residents who graduated in 2009 and 2010.

Materials and methods: The list of radiology residents and imaging theses were obtained from the French internet database of university theses. The main characteristics of the theses were recorded and correlated with associated publications identified by scanning the PubMed database. All other publications by French radiology residents not related to the theses were also obtained, described and compared to published theses.

Results: Seventy-nine out of 224 (35.3%) medical theses written by French radiology residents in 2009 and 2010 were transformed into articles published in Medline-indexed journals. Residents were first authors in 69% (60/87) of these articles. The factors associated with publication of the thesis were a prospective design ($P=0.01$) and the publication as a first author of an original study not related to the thesis ($P=0.01$). Seventy-one percent of the residents had published at least one other article, including 36.6% as first authors.

Conclusion: Academic productivity of French radiology residents is high thanks to published theses and other articles.

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In France, residents must defend a medical thesis at the end of their residency to obtain the title of medical doctor. Residents with a medical specialty must also defend a report in their academic specialization to become a specialist. Thus, each French radiology resident must conduct at least two academic studies during their 5 year-residency to graduate. These studies, whose goal is to introduce residents to clinical or experimental research, are very different from daily clinical practice. It is interesting to note that, research methodology is currently only taught in a single training session during the residency, and historically the academic medical authorities did not request publication.

Recently, the French Academic College of Radiology (collège des enseignants de radiologie de France [CERF]) has addressed this issue and decided that submission to a peer-review journal should be mandatory before defense of the medical specialization report. Although the total number of new residents who have begun a radiology residency program has rapidly increased from 166 in 2010 to 240 in 2014, the number of academic radiologists has remained stable. Thus, supervising the studies by all these additional residents will be challenge, especially if publication and not only submission of these studies, becomes mandatory by the CERF in the near future.

Nevertheless, this submission process is still not mandatory for the medical thesis. Thus if students produce their thesis for purely administrative reasons, it is difficult to evaluate the individual academic benefit of this experience. Besides being an indicator of the scientific quality of the study, and/or the dynamism of the team they are working with, publication of the medical thesis in indexed peer-review journals can also be a sign of the resident's interest in the academic field.

There are no existing studies to date on the publication rate of theses or the overall publication productivity of French radiology residents. Previous studies have reported that the publication rate of medical theses for all French residents was below 20% [1,2]. Thus we felt that it was important to have an overview of the research productivity of French radiology residents.

The aim of this study was to assess and analyze the publication rate of medical theses and the overall publication productivity of radiology residents who graduated in 2009 and 2010.

Materials and methods

Identification of residents and theses

The list of all radiology residents who had defended their medical thesis in 2009 and 2010, and if available the title of their medical thesis, was obtained from the CERF. To complete this list, we performed a cross-check on the national internet database of university theses (www.sudoc.abes.fr), and searched for all medical theses on imaging during the same period. The title and abstract of the medical theses were available on the website. To make sure that all the theses on imaging were published by radiology residents, we checked their medical specialty at the French National Medical Council (Conseil national de l'ordre des

médecins [CNOM], <http://www.conseil-national.medecin.fr/annuaire>). All theses defended by non-radiologists residents were excluded. The year the thesis was defended (2009 or 2010) was also recorded.

Identification of residents' publications

Publication in Medline-indexed journals was identified by scanning the PubMed database (<http://www.ncbi.nlm.nih.gov/pubmed/>) using the last name and the initial letter of the first name of the resident. For women, the married name was also used when known.

First, we checked if the medical theses were published in Medline-indexed journals, comparing the titles and the abstracts of the articles with the theses. We then recorded all other articles published by each resident over a period ranging from 5 years before the defense of the medical thesis to 3 years after the defense of the thesis (from January 2004 to December 2012 for medical theses defended in 2009, and from January 2005 to December 2013 for medical theses defended in 2010). To avoid mistakes from homonyms, we checked the affiliation (France or city), and the topic of the publication (imaging or not).

Theses and publications characteristics

All identified medical theses and publications were analyzed by two radiology residents (GC and VDR). For each individual medical thesis or publication, the following items were recorded: a radiological subspecialty (e.g. neuroradiology, abdominal and digestive imaging... as defined by the French Society of Radiology), diagnostic or interventional radiology, the main modality of imaging (i.e. plain radiography, ultrasound (US), computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine, and multimodal imaging when different imaging techniques were used), human, technical or animal study, retrospective or prospective design, the type of report (i.e. case report, case series, review, original article, or letter).

The following items were also recorded for each publication: the ranking of the resident among the authors and the total number of authors, the name of the journal, the language of the journal, the year of publication, and the impact factor of the journal according to the Thompson Reuters Journal Citation Report® on the date of publication. For articles published in 2013 and 2014, the 2012 impact factor was considered and if a journal had no associated impact factor, it was assigned a value of zero.

For journal ranking, we used SIGAPS software which is a bibliometric system developed in France to analyze Medline-indexed publications [3,4]. This tool is used for bibliometric activity-based funding of French hospitals. Journals are ranked on a six level quality scale (A, B, C, D, E and not ranked) derived from the impact factors of the journal compared to others in the same medical or scientific specialty.

Statistical analyses

Values are expressed as means and standard deviations, or medians and interquartile ranges, and percentages, as appropriate. The Chi² or Fisher exact test was used for the comparison of categorical variables. The Mann–Whitney

test was used for the comparison of continuous variables. A P -value < 0.05 was considered to be significant. The analyses were performed with the Statistical Package for the Social Sciences (SPSS) software (version 20.0, SPSS Inc., Chicago, IL).

Results

Theses characteristics

During the study period, a total of 13,508 medical theses were identified on the SUDOC database (2009 = 6803, 50.4%; 2010 = 6705, 49.6%, $P > 0.05$). Among these, 224 medical theses were identified by radiology residents (2009 = 123, 54.9%; 2010 = 101, 45.1%, $P > 0.05$). Table 1 summarizes the characteristics of these theses. Briefly, they were mostly retrospective studies ($n = 170$, 75.9%), involving human subjects ($n = 219$, 97.8%) that focused on diagnostic imaging ($n = 185$, 82.6%). They were mainly original studies ($n = 188$, 83.9%), followed by reviews ($n = 32$, 14.3%), and case series ($n = 4$, 1.8%). There were no case reports or letters.

The most frequent imaging modalities were MR imaging ($n = 105$, 46.9%), CT ($n = 55$, 24.6%), and multimodal imaging ($n = 28$, 12.5%). The most frequent radiological subspecialties were abdominal and digestive ($n = 44$, 19.6%), neuroradiology ($n = 39$, 17.4%), musculoskeletal ($n = 36$, 16.1%), genitourinary ($n = 29$, 12.9%), and cardiovascular imaging ($n = 24$, 10.7%).

Published theses

Between November 2004 and November 2014, 79/224 medical theses defended by French residents in 2009 and 2010 were developed into articles published in Medline-indexed journals resulting in a publication rate of 35.3%. The 2009 and 2010 publication rates were 36.6% (45/123) and 33.7% (34/101) ($P = 0.65$), respectively. Eighty-seven articles were considered for the following analysis, since 8 medical theses resulted in two publications (3.6%).

The mean delay between the defense of the medical thesis and the related publication was 19 months ± 16 (median 2 years, IQR 12–36). Only 4 medical theses were published prior to the defense (5.1%), and 8 were published more than 3 years after the defense (10.1%) (Fig. 1). The resident was the first author in 69% (60/87) of the published articles, and the second in 19.5% (17/87). Most of the articles related to the medical theses were published in English ($n = 58/87$, 66.7%).

A total of 55 theses (63.2%) were published in seven journals, in decreasing order: *Diagnostic and Interventional Imaging* which was previously called *Journal de Radiologie* ($n = 25$, 28.7%), *Radiology* ($n = 7$, 8%), *European Radiology* ($n = 7$, 8%), *Journal of Neuroradiology* ($n = 6$, 6.9%), *European Journal of Radiology* ($n = 4$, 4.6%), *American Journal of Roentgenology* ($n = 3$, 3.4%), and *American Journal of Neuro-radiology* ($n = 3$, 3.4%). The other 27 published theses were published in 24 journals, including 11 non-radiological journals. The mean impact factor of the journals was 2.2 ± 2.2 ,

Table 1 Characteristics of the theses in relation to their subsequent publication.

	Total (%)	Published (%)	Not published (%)	P -value
<i>Number</i>	224	81 (36)	143 (64)	
<i>Study design</i>				
Retrospective	170 (76)	54 (32)	116 (68)	0.001
Prospective	54 (24)	28 (52)	26 (48)	
Diagnostic imaging	185 (83)	70 (38)	115 (62)	0.276
Interventional imaging	39 (17)	11 (28)	28 (72)	
<i>Imaging modality</i>				
MRI	105 (47)	38 (36)	67 (64)	
CT	55 (25)	21 (38)	34 (62)	
US	11 (5)	4 (36)	7 (64)	0.991
Plain radiography	25 (11)	8 (32)	17 (68)	
Multimodality	28 (12)	10 (36)	18 (64)	
<i>Type of subjects</i>				
Human	219 (98)	79 (36)	140 (64)	1.000
Experimental	5 (2)	2 (40)	3 (60)	
Technical	0	0	0	
<i>Radiology subspecialty</i>				
Gastrointestinal imaging	44 (20)	14 (32)	30 (68)	
Neuroradiology	39 (17)	11 (28)	28 (72)	
Musculoskeletal	36 (16)	15 (42)	21 (58)	
Genito-urinary	29 (13)	14 (48)	15 (52)	
Cardiovascular	24 (11)	8 (33)	16 (67)	
Breast	15 (7)	6 (40)	9 (60)	0.281
Pediatrics	14 (6)	4 (29)	10 (71)	
Thoracic	13 (6)	8 (62)	5 (38)	
Head and Neck	8 (4)	1 (13)	7 (87)	
Other	2 (1)	0 (0)	2 (100)	

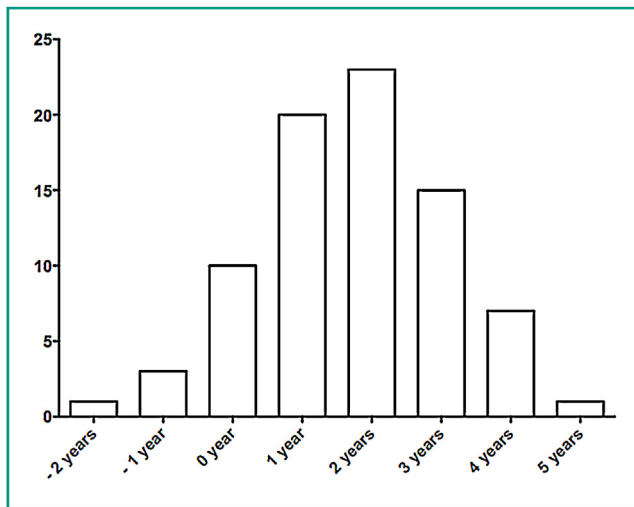


Figure 1. The delay between defense of the thesis and publication of the related article(s).

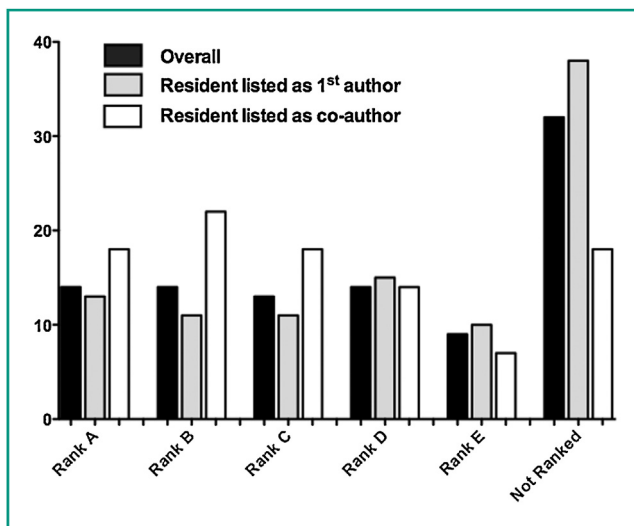


Figure 2. Journal rank of published theses according to the rank of the resident among the authors. Residents were less frequently first authors of an article, published in rank A or B journals ($P=0.0165$).

(median 1.6 (range 0–9.3)). The impact factor was significantly lower when the resident was the first author (median 1.21 vs 2.09, $P=0.035$).

Journal rank is presented in Fig. 2. The journal ranking was significantly different depending on the rank of the resident among the authors ($P=0.0165$). When the resident was the first author of the article, 25% of the medical theses were published in rank A or B journals, and 38.3% in non-ranked-journals. On the other hand, when the resident was not the first author, 40.7% were published in rank A or B journals, and 18.5% in non-ranked-journals.

Thesis characteristics associated with publication

Factors associated with publication are presented in Table 1.

A prospective study design was the only factor associated with publication on univariate analysis (52% vs 32%, $P=0.01$).

The highest publication rate of the medical subspecialties concerned thoracic imaging (61.5%, 8/13), followed by genitourinary imaging (48.3%, 14/29), breast imaging (40.0%, 6/15), and musculoskeletal imaging (38.9%, 14/36). Other specialties had a publication rate below the mean (36%) (Fig. 3).

Residents' other publications

Besides the thesis-based article(s), radiology residents published a total of 506 articles up to 3 years after the defense of their medical thesis. Thirty-six of these (7.1%) had at least two residents among the authors. Thus, 160 residents (71.4%) were listed as the first author or co-author of at least one article not related to their thesis during the study period. Publications were mostly case reports ($n=194$, 38.3%), original studies ($n=167$, 33%), and reviews ($n=115$, 22.7%). There were significantly more case reports and fewer original articles ($P<0.001$) than for the published theses (Fig. 4). The subspecialties of the articles are presented in Fig. 5. Neuroradiology was the most common subspecialty.

A total of 249 articles (49.2%) were published in six journals, in decreasing order: *Diagnostic and Interventional Imaging* and the same publication which was previous called *Journal de Radiologie* ($n=171$, 33.8%), *Journal of Neuro-radiology* ($n=26$, 5.1%), *European Radiology* ($n=22$, 4.3%), *Radiology* ($n=9$, 2%), *Presse Médicale* ($n=12$, 2.4%), and *American Journal of Neuroradiology* ($n=9$, 2%). The other 257 published articles were published in 147 journals, with fewer than 9 articles published in each.

The rank of the journals is presented in Fig. 6. Forty-nine articles (9.7%) were published in rank A journals. The mean impact factor was 1.79 ± 2.5 (median 1.03 (range 0–33.63)). Unlike for published theses there was no significant difference in journal rank ($P=0.876$) or journal impact factor ($P=0.840$) according to the rank of the resident among the authors. However the impact factor of these articles was lower than that for medical theses ($P=0.047$).

Eighty-two residents (36.6%) were the first authors of a total of 147 articles. The rate of resident first authors was significantly lower in publications not related to the thesis ($P<0.001$). The mean impact factor of these articles was 1.91 ± 3.32 (median 0.73 (range 0–33.63)). There was no difference in journal rank ($P=0.943$) or impact factor ($P=0.731$) compared to thesis-related articles published as first author (Fig. 7).

Publication of the thesis as an article was more frequent for residents who were first authors of an article not related to the medical thesis (45.6% vs 31.7%) but this was not significant ($P=0.051$). When looking at the type of article, 20.3% of the residents who were first authors of an original study also published their thesis, compared to 8.3% of those who were not ($P=0.01$) (Table 2).

Discussion

This study showed that around 35% of the medical theses defended by French radiology residents in 2009 and 2010

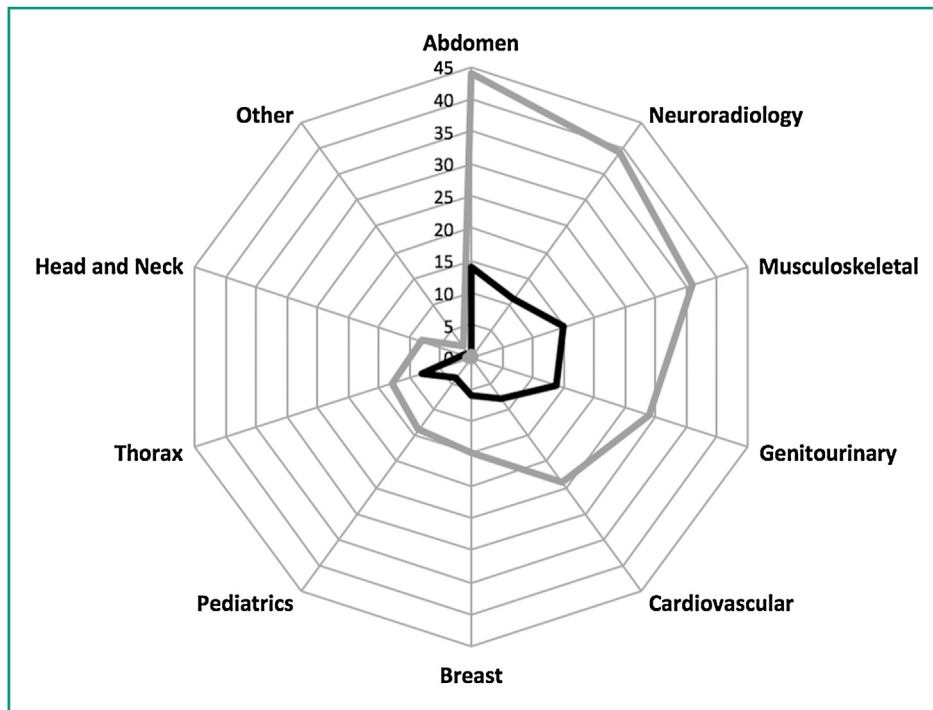


Figure 3. Radar charts showing the number of theses (gray line) and the number of related publications (black line) according to the imaging subspecialty.

were later published in Medline-indexed journals. Overall, only 69% of young radiologists were first authors of the related article. During a period of up to 3 years after their residency, 71.4% of the residents published at least one other article.

The publication rate of medical theses defended by radiology residents is higher than that reported in French medical universities by Benotmane et al. (11.3%) and Salmi et al. (17%) [1,2] for all medical specialties. It is also higher than the publication rates reported in other countries which ranges from 5.8% in Peru to 30% in India [5–8].

Sixty-nine percent of the residents were first authors of the article written from their thesis, and around one third were in another position. This rate can be explained by several factors, including the personal involvement of the resident but also the publication policies of the different teams. Indeed, on one hand, teams may be discouraged from ranking the resident as the first author because of pressure to publish for radiologists with university positions, and potential shortfall in academic scoring, mostly through the SIGAPS scoring system. On the other hand publication as a first author can be highly motivating for the resident. Interestingly we found that the journal rank was better when the resident was not first author of his/her thesis.

The only characteristic of medical theses associated with publication was a prospective design. This has already been described as a strong predictive factor of publication for oral abstracts presented at scientific meetings [9,10]. Because most prospective studies require funding and approval from the ethics committee, we can hypothesize that these research projects were considered worthy for publication and that thesis supervisors may have been more involved in obtaining publication. In comparison, Itagaki and Pile-Spellman who evaluated factors associated with research productivity in all university radiology departments in the United States found that high NIH funding was associated with a better quality publication, while the number of residents was associated with an increase in the

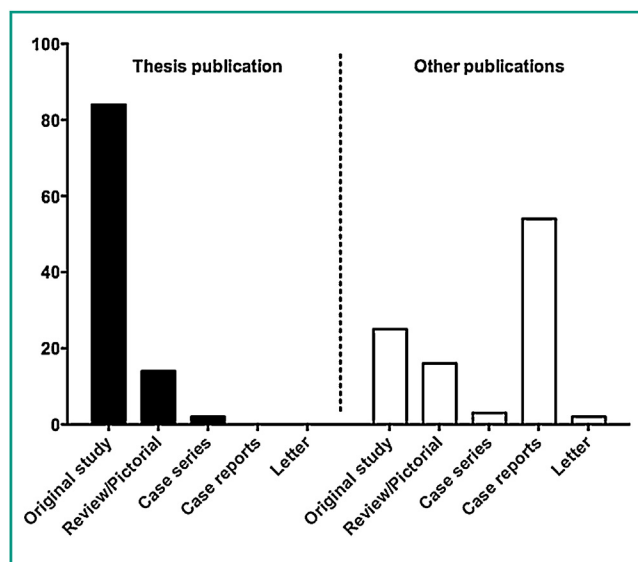


Figure 4. Type of articles published by residents as first author during and up to 3 years after their residency (expressed as percentage). There were significantly more original studies in the publications related to the thesis, while there were significantly more case reports in publications not related to the thesis ($P < 0.001$).

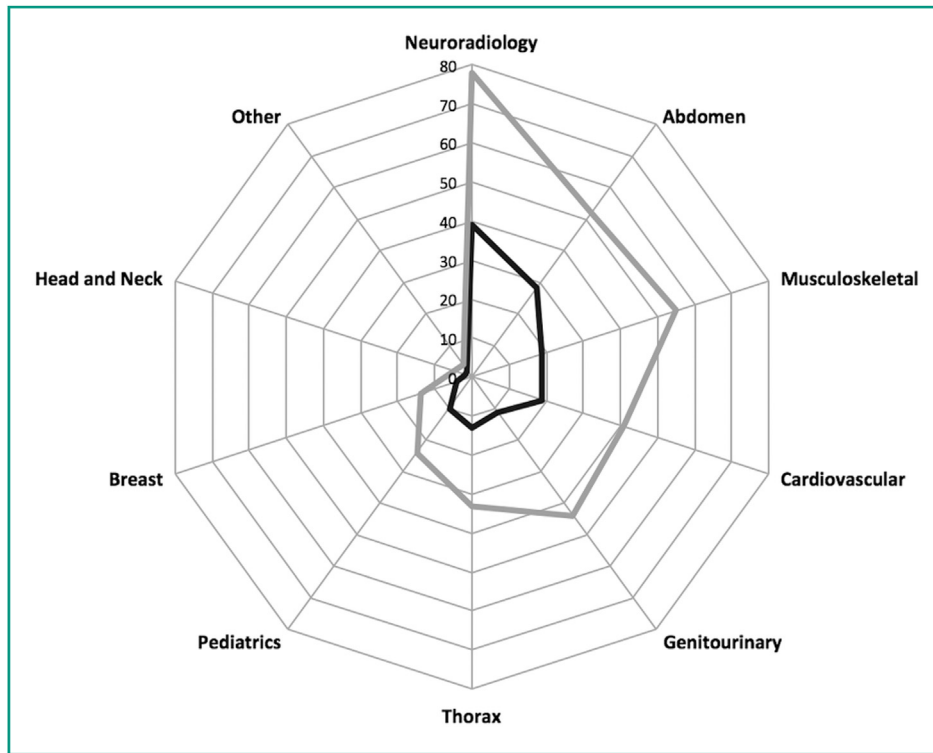


Figure 5. Radar charts showing the number of articles (besides the thesis publication) with the resident ranked as first author (black line) and in another position (gray line) according to the imaging subspecialty.

volume of publications [11]. Several articles have studied factors associated with resident publications. Time spent doing research appears to be the major predictive factor of research productivity [12,13]. Namdari et al. reported that the reduction in resident work-hours in the United States was associated with an increase in resident publications [14]. It has also been shown that a research methodology program [15,16] and mentoring [17] has a positive

influence on the publication rate. Several authors have suggested that involving undergraduate students in research and article writing could also improve productivity [1,18]. All these factors offer avenues to improve the productivity of French radiology residents.

Besides their thesis, 71.4% of residents published at least one other article during the study period. As previously stated, French residents also must defend a specialization report to graduate. Unlike the medical thesis, specialization

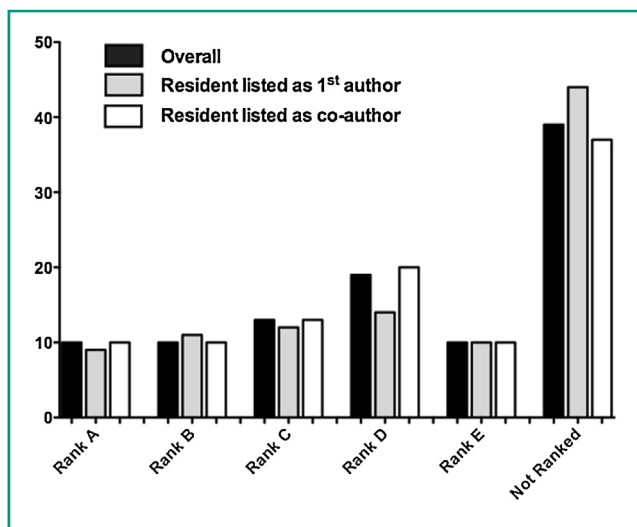


Figure 6. Journal rank of articles besides the thesis, published by residents during their residency and up to 3 years afterwards, according to the rank of the resident among the authors. There was no difference in journal ranking ($P=0.876$).

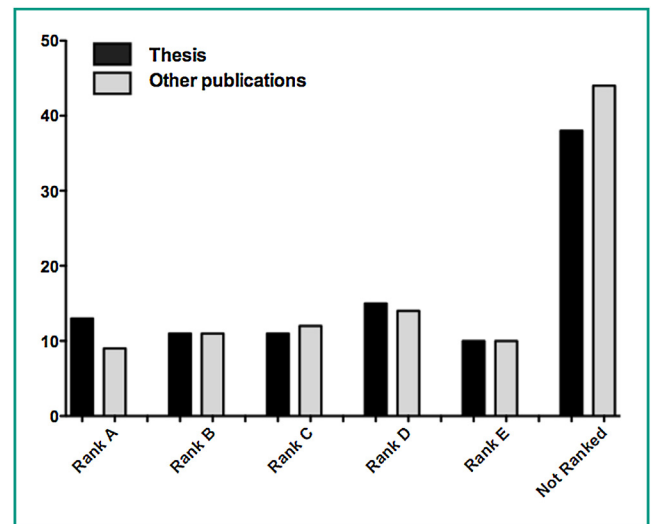


Figure 7. Comparison of the distribution of journal rank for articles with resident first authors related or not to the thesis. There was no difference in journal ranking ($P=0.943$).

Table 2 Publication of the thesis according to the characteristics of articles not related to the thesis published during and up to 3 years after the residency.

	Residents	Thesis publication		P-value
	n = 224	Yes n = 79	No n = 145	
<i>Publication of at least one article not related to thesis</i>	160 (71.4%)	61 (77.2%)	99 (68.3%)	0.150
1 article	57 (25.4%)	22 (27.8%)	35 (24.1%)	0.198
2 articles	36 (16.1%)	11 (13.9%)	25 (17.2%)	
3 articles	20 (8.9%)	5 (6.3%)	15 (10.3%)	
> 3 articles	47 (20.1%)	23 (29.1%)	24 (16.6%)	
<i>Authorship</i>				
Listed as first author	82 (36.6%)	36 (45.6%)	46 (31.7%)	0.140
Co-author	78 (34.8%)	25 (31.6%)	53 (36.6%)	
<i>Date of first publication</i>				
Before thesis defense	81 (36.2%)	34 (43%)	47 (32.4%)	0.332
After thesis defense	79 (35.3%)	27 (34.2%)	52 (35.9%)	
<i>Date of first publication as first author</i>				
Before thesis defense	43 (19.2%)	19 (24.1%)	24 (16.6%)	1.000
After thesis defense	39 (17.4%)	17 (21.5%)	22 (15.2%)	
<i>Type of article published^a</i>				
Original study	83 (37.1%)	36 (45.6%)	47 (32.4%)	0.051
Review/pictorial	74 (33%)	26 (32.9%)	48 (33.1%)	0.976
Case series	22 (9.8%)	5 (6.3%)	17 (11.7%)	0.195
Case reports	90 (40.2%)	34 (43%)	56 (38.6%)	0.519
Letter	7 (3.1%)	3 (3.8%)	4 (2.8%)	0.699
<i>Type of article published as first author^a</i>				
Original study	28 (12.5%)	16 (20.3%)	12 (8.2%)	0.010
Review/pictorial	22 (9.8%)	9 (11.4%)	13 (9%)	0.560
Case series	5 (2.2%)	0 (—)	5 (3.4%)	0.160
Case reports	49 (21.9%)	22 (25.3%)	27 (18.6%)	0.110
Letter	2 (0.9%)	1 (1.3%)	1 (0.7%)	1.000

^a The total exceeds the number of residents because certain residents published more than one article. Therefore, the types of articles were considered independent and tested separately.

reports are not referenced in a centralized database and thus their publication rate cannot be determined. However, we can hypothesize that at least some of these studies are included in these publications. It is interesting to note that articles not related to the thesis were less frequently original studies and reviews, and less frequently published in high-level journals.

We found a positive correlation between publication of the medical thesis by the resident and publication of unrelated original studies as a first author. These results can be compared to those of Macknin et al. who reported that orthopedic residents who published during their residency were more likely to publish again after graduation [19]. Interestingly, the impact factors of articles not related to were lower than those related to the medical thesis, and residents were less frequently listed as the first author. The difference in impact factor might be due to the higher rate of case reports in the articles not related to the thesis, while the lower rate of first-authorship may be linked to the limited contribution of the residents to these papers.

Overall, 19% of the residents had published at least one article as a first author before they defended their thesis. This rate is low especially compared to other countries where academic activity is more important and valued

during resident training. In the United States, for example, where residents often dedicate one or two years to research, Morgan et al. reported that 50% of 1098 oncology residents were first authors of at least one original study or review during their residency (articles published more than 3 months after graduation were excluded from this study) [20]. It shows that French medical academic authorities are just beginning to develop a more systematic and positive publication and academic culture.

The proportion of medical theses published in English (66.7%) was similar to that reported by Benotmane et al. in 2012 (70%) [1], but lower than the articles issued from the French Congress of Radiology (89%) [9]. This high proportion can be explained by the gradual increase in English publications by French medical teams and residents, as shown by the recent decision of the editorial board of the Journal of the French Society of Radiology (Diagnostic Interventional Imaging, formally known as ‘‘Journal de radiologie’’) to shift publication to online English articles [21].

Our study has several limitations. First, to assess the overall publication rate, we included articles published up to 3 years after defense of the medical thesis. Although this may seem long it is realistic and consistent with publications in the literature. Indeed, Elliot et al. used a two-year

publication interval after graduation [22]. Furthermore in a study of publications from radiology meetings, Arrivé et al. found that 94% of the articles were published within three years after the meeting [23]. Second, we decided to define completion of the residency as the year the medical thesis was defended but in France medical thesis can also be defended before the end of the residency. This is less common, and we estimated that it was compensated by the 3-year delay, which also covers the fellowship which is mainly done in radiology. Third, certain theses and/or residents could have been missed in the SUDOC database due to the retrospective design of our study. In France, when residents defend their medical thesis, they must leave a copy in the University library of their medical faculty and each University library must declare it to the SUDOC database. As together the promotions who graduated in 2009 and 2010 had a total of 245 residents [24], we can estimate that less than 10% of thesis defended during the study period were not declared to the SUDOC database by University libraries. Therefore, we believe that underreported theses shall not affect the results of the present work.

In conclusion, the publication rate of French radiology resident theses is higher than previously reported in France for all specialties, but significant effort must be made to increase the publication rate and involve more residents in academic research.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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