



REVIEW ARTICLE

Analysis of 100 most cited articles on forensic odontology



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Abstract *Objectives:* Bibliometric analysis of best-cited papers brings awareness about the influential publications and trends in the literature on a particular topic. This will help not only the researchers and academicians but also the students for selecting quality landmark articles. With this view in mind a bibliometric analysis was performed to identify the 100 top-cited papers on Forensic Odontology (FO) in the literature.

Materials and methods: A search was performed using Scopus database in August 2019. The articles were further reviewed and basic standard information related to bibliometric analysis was recorded.

Results: The 100 most cited articles were published from 1985 to 2014 (77% published after 2001). The most frequently cited article received 259 citations, whereas the least received 31 (mean citations 58.78 ± 33.14). There were 16 different journals with Forensic Science International having the most number of articles ($n = 36$). One author had 16 articles while 8 authors had 4 or more articles published in the top 100 list. Belgium was the country with most number of articles ($n = 17$) followed by United States ($n = 16$). In terms of document type, 87 were original research, 7 conference papers and 6 reviews. Five organizations funded 5 of the top 100 articles. Katholieke Universiteit Leuven, Belgium affiliated the most documents ($n = 16$). Majority of the papers were

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related to age estimation (46) followed by victim identification (30), mass disaster (9), bite mark analysis (8), sex determination (5), race determination (4), dental DNA analysis (3), palatal rugae pattern (2) and lip prints (1).

Conclusion: This is first of its kind citation analysis of the 100 most cited articles in the field of FO. The results of this paper will help the researchers, academicians and students for appropriate article referrals.

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1. Introduction

Forensic odontology (FO) is a very distinctive branch of dentistry, which deals with the various aspects of forensic investigations. The role of FO is widely known and has been proved in the literature through various laboratory investigations and actual incidences such as victim identifications in mass disasters (Divakar, 2017; Balachander et al., 2015). FO helps in victim identification by virtue of variety of unique means, which has potential to confirm the age, gender, and person identification (Divakar, 2017). Extensive work has been carried out on FO with some landmark publications (Jeddy et al., 2017).

To measure the academic influence and impact of an article, citation analysis is a commonly used bibliometric tool. Scopus database and Web of Science are the most widely used tool for retrieving citation and related matrixes. The number of citations received by an article is a mark of distinction. Thus by recognizing 100 best-cited papers in a particular field can greatly help researcher and academicians to prioritize the bibliography for reference in the vast ocean of publications.

Bibliometric studies have been carried out in various fields and also in dentistry on subjects such as oral submucous fibro-

sis (Gondivkar et al., 2018a), cone beam computed tomography (Gondivkar et al., 2018b), ameloblastoma (Gondivkar et al., 2019), endodontics (Fardi et al., 2011), orthodontics (Hui et al., 2013), maxillofacial surgery (Brennan and Habib, 2011), oral cancer (Pena-Cristobal et al., 2018; Hassona and Qutachi, 2019), etc. To our knowledge, an inclusive study of the most prominent articles in the field of FO has not been undertaken till date. Therefore, the emphasis of this study was distinguishing the 100 most cited articles on FO and investigating their study characteristics to recognize the information and progress in the field.

2. Materials and methods

2.1. Data source

Scopus database was used to retrieve the data regarding the citation information of the published papers on FO. The data was accessed on 25th August 2019 and hence all the citations related matrixes were of this time point. The search used the medical term “forensic odontology” and this term was searched in the keywords, titles and text options of the Scopus

database. The top100 highly cited articles obtained from the search were then arranged according to the decreasing number of their citation counts. Citation density was also calculated by dividing the total number of citations with the number of years after publication of the paper; this information was used in cases where articles received equal number of citations. The relevancy of these articles to FO was evaluated by studying their titles and abstracts. There were no limitations for the time, language or type of articles.

2.2. Data extraction

The previously used methodology was used in the present study for retrieval of relevant information from the articles (Gondivkar et al., 2018a,b). Two independent authors evaluated all the selected articles. Any disagreement between the two authors was solved by consulting the third author.

Collaboration among authors, countries and keywords co-occurrence network was developed using the VOSviewer software (Version 1.6.13; Leiden University).

3. Results

Total 1153 articles were obtained from the search with h index and h index after excluding self-citations of 51 and 48 respectively. Based on the citations received, 100 most influential

articles were sorted which account for 8.7% of the total articles obtained through the search (Supplementary file 1).

3.1. Citation analysis

The 100 highly cited articles have received 5878 total citations. The number of citations ranged from 31 (article rank nos. 96–100) to 259 (top article) with a mean of 58.78 (SD = 33.14) citations per article. More than 200 citations were received by the articles titled “The problem of aging human remains and living individuals: A review” and “Dental age estimation in Belgian children: Demirjian’s technique revisited” (Cunha et al., 2009; Willems et al., 2001). Five articles received 31 citations, and hence have been ranked in the list as per their citation density. The overall h index and h index after removal of self-citations was 51 and 48 respectively.

A correlation analysis was performed between duration of publication and number of the citations received. Although there was a positive correlation but the relationship between them was weak ($R = 0.0413$; $p = 0.68$).

The article with the highest citation density (25.9, nearly 26 citations annually) was a review paper of Cunha et al, titled “The problem of aging human remains and living individuals: A review.” It was published in Forensic Science International in 2009 (Cunha et al., 2009). The article that received the lowest citation density (0.97) was of Fischman, titled “The use of

Table 1 Top Journals with their individual contribution to the 100 most-cited articles on forensic odontology.

Sr. no.	Journal Name	Impact factor (2018/2019)	Quartile	Category/ies	Number of articles
1	Forensic Science International	1.990	1	Medicine	36
2	Journal of Forensic Sciences	1.438	2	Biochemistry, Genetics, Molecular Biology	29
3	International Journal of Legal Medicine	2.094	1	Medicine	12
4	Journal of Forensic Odontology	NA*	3	Medicine	05
5	Pattern Recognition	5.89	1	Computer Science	03
6	Journal of the American Dental Association 1939	2.57	1	Dentistry, Medicine	03
7	Australian Dental Journal	1.28	1	Dentistry	02
8	International Dental Journal	1.628	2	Dentistry	02
9	American Journal of Forensic Medicine and Pathology	0.539	3	Medicine	01
10	American Journal of Physical Anthropology	2.662	1	Medicine, Social Sciences	01
11	Archives of Oral Biology	1.663	2	Biochemistry, Genetics and Molecular Biology, Dentistry, Medicine	01
12	European Journal of Oral Sciences	1.81	1	Dentistry	01
13	IEEE Transactions on Information Forensics and Security	6.211	1	Computer Science, Engineering	01
14	Indian Journal of Dental Research	NA*	3	Dentistry, Medicine	01
15	International Journal of Osteoarchaeology	1.18	1	Arts and Humanities, Social Sciences	01
16	Journal of the Canadian Dental Association	0.759	3	Dentistry	01

* Not available in the SCI journal list.

Table 2 Distribution of the 100 top-cited articles on forensic odontology according to year, country of origin, type of document and affiliations.

Item	Description	Number of articles
Year-wise distribution of papers	1980s	4
	1990s	19
	2000s	68
	2010s	09
Country of Origin with five or more papers	Belgium	17
	United States	16
	Italy	11
	Australia	9
	Spain	7
	United Kingdom	7
	Canada	5
Type of document	Original Research	87
	Conference papers	7
	Review articles	6
Affiliations with five or more papers	KU Leuven, Belgium	16
	UniversitA degli Studi di Macerata, Italy	6
	Universiteit Hasselt, Belgium	5
	UniversitA Politecnica delle Marche, Italy	5

medical and dental radiographs in identification.” It was published in *International Dental Journal* in 1985 (Fischman, 1985).

3.2. Journals analysis

16 different journals were associated with the 100 most cited articles (Table 1). *Forensic Science International* (36 articles) topped in total contribution followed by *Journal of Forensic Sciences* (29 articles) and *International Journal of Legal Medicine* (12 articles). Other journals, which contributed 2 or more articles, were *Journal of Forensic Odonto Stomatology* (n = 5), *Pattern Recognition* (n = 3), *Journal of the American Dental Association* (n = 3), *Australian Dental Journal*, *International Dental Journal* (n = 2). Out of 16, 8 journals contributed single article each.

Majority of the papers were published in the subject heading of *Medicine* (n = 84; citations: 4113, h index: 47); *Biochemistry*, *Genetics and Molecular Biology* (n = 25);

Dentistry (n = 11; citation: 518; h index: 11) followed by *Social Sciences* (n = 10; citations: 248; h index: 6).

Among all the 16 journals, 9 (56.25%) were ranked in the first quartile, 3 (18.75%) in the second and 4 (25%) in the third category.

The impact factors of the journals that published the 100 most cited articles ranged from 0.539 to 6.211 (mean 1.98 ± 1.77). Majority (74%) of the top 100 articles were published in journals with impact factors below 2. The journal with the highest impact factor (6.211) was *IEEE Transactions on Information Forensics and Security*, which contributed one article whereas, *American Journal of Forensic Medicine and Pathology* was the journal with lowest impact factor (0.539) and it also published only one article. The article published in *IEEE Transactions on Information Forensics and Security* journal was of [Nomir and Abdel-Mottaleb in 2007](#) about the identification of humans from dental X-ray images based on the shape and appearance of the teeth. Only two journals (*Pattern Recognition* and *IEEE Transactions on Information Forensics and Security*) had the impact factor of more than five and 3 journals (*International Journal of Legal Medicine*, *Journal of the American Dental Association* and *American Journal of Physical Anthropology*) had impact factors of more than two. The impact factors of 2 journals (*Journal of Forensic Odonto Stomatology* and *Indian Journal of Dental Research*) were not available on the SCI Journal list.

All the 100 highly cited articles were published in English language over the past 29 years from 1985 to 2014. The oldest and the most recent article was published in “*Forensic Science International*” journal by [Ogino et al. \(1985\)](#) and [Ambarkova et al. \(2014\)](#) respectively. The greatest output of the top cited articles was noticed in the decade 2000s, about 77 articles of the top 100 were published after 2001 (Table 2). 68 articles were published in the decade 2000s, 19 articles in the 1990s and 9 articles in 2010s. The year 2007 had the highest number of publications of the top 100 articles (n = 12). 16 articles of the top 100 list were published in and after 2010.

3.3. Authors and countries of origin

Total 159 authors were associated with the 100 most cited papers. The number of authors for a particular paper ranged between one (11 papers) and nine (1 paper). Total 15 papers had two authors associated with it. Twenty-two and eighteen papers were associated with three and four researchers respectively; whereas remaining 32 articles were credited to five or more authors. Of these 100 most cited articles, five persons authored five or more of the 100 most-cited articles. G. Willems was recognized as the most prolific author with

Table 3 Authors with at least 5 articles included in the top 100 cited papers on forensic odontology.

Sr. no.	Name of author	First author	Co-author	Last author	Total
1	Willems G.	3	0	13	16
2	Thevissen P.W.	7	0	0	7
3	Cameriere R.	5	1	0	6
4	Ferrante L.	1	4	1	6
5	Fieuws S.	0	5	0	5

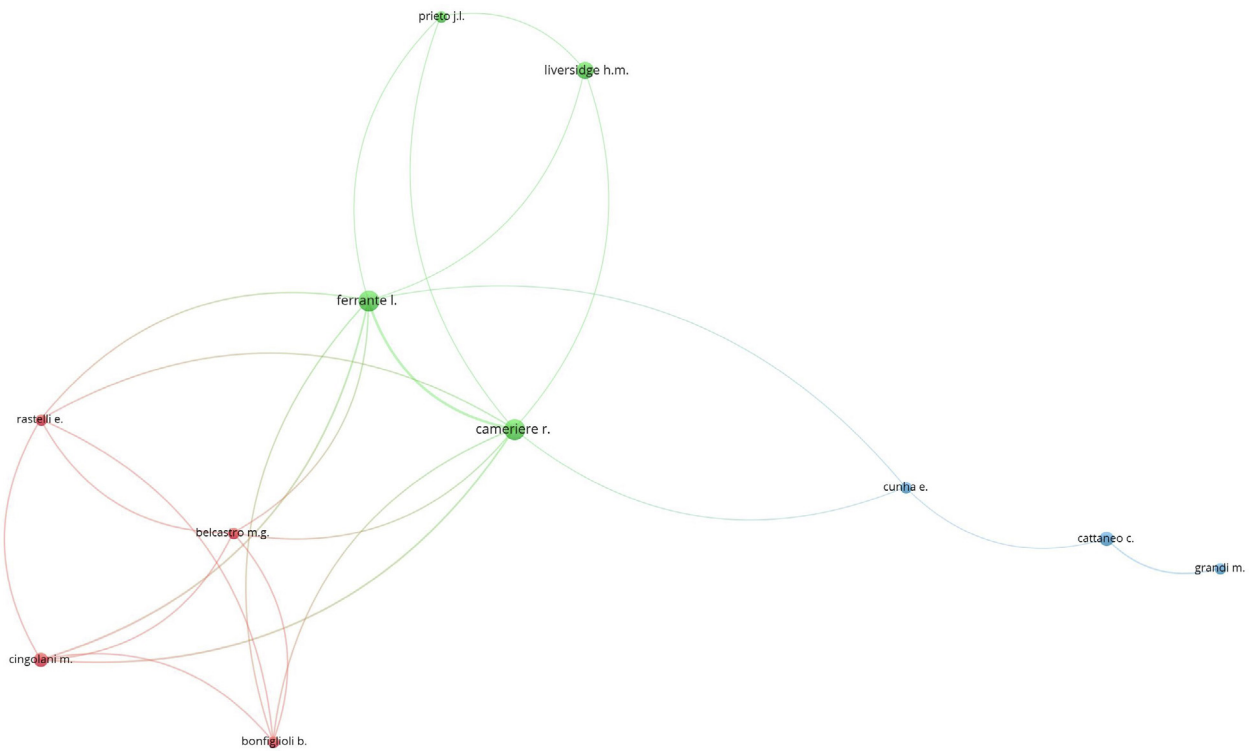


Fig. 1 Coauthor contribution with 2 or more articles with their network in the top-cited papers.



Fig. 2 Collaboration among countries.

Table 4 Topic-wise bifurcation of the 100 best cited paper on forensic odontology.

Topic	Original Research	Review articles
Victim identification	30	01
Age estimation	46	03
Sex determination	05	0
Race determination	04	0
Bite-mark analysis	08	0
Lip prints analysis	01	0
Palatal rugae pattern analysis	02	0
Salivary and Pulpal DNA analysis	03	0
Mass Disasters	09	01

16 illustrious articles (3 as first author and 13 as last author), followed by P.W. Thevissen, R. Cameriere and L. Ferrante with 7, 6 and 6 papers respectively. Table 3 displays the list of authors with five or more contributions to the 100 most cited articles on FO. A collaboration network was generated for the co-authors who contributed to 2 or more articles (Fig. 1). Cameriere R. and Ferrante L. had collaborations with 7 and 6 authors each.

The first author of each article was searched and their country was recorded. Based on this search, it was observed that investigators from the thirty-one different countries had contributed to the 100 most cited articles (Table 2). Belgium contributed maximum number of publications (n = 17) followed by United States (n = 16) and Italy (n = 11). India had only 4 publications to its credit. Fig. 2 shows collaboration networks of countries. Italy, Spain, Denmark and Germany had the highest number of international collaborations.

3.4. Type of document

In terms of document type, 94 were articles (7 of them classified both as articles and conference papers) and 6 reviews (Table 2).

3.5. Funding sponsors and affiliations

Five organizations funded 5 of the top 100 articles. Mashhad University of Medical Sciences, National Aeronautics and Space Administration, National Institute of Justice, Office of Justice Programs, U.S. Department of Justice were the 5 organizations to fund one article each among the top 100 articles. Katholieke Universiteit Leuven, Belgium affiliated the most

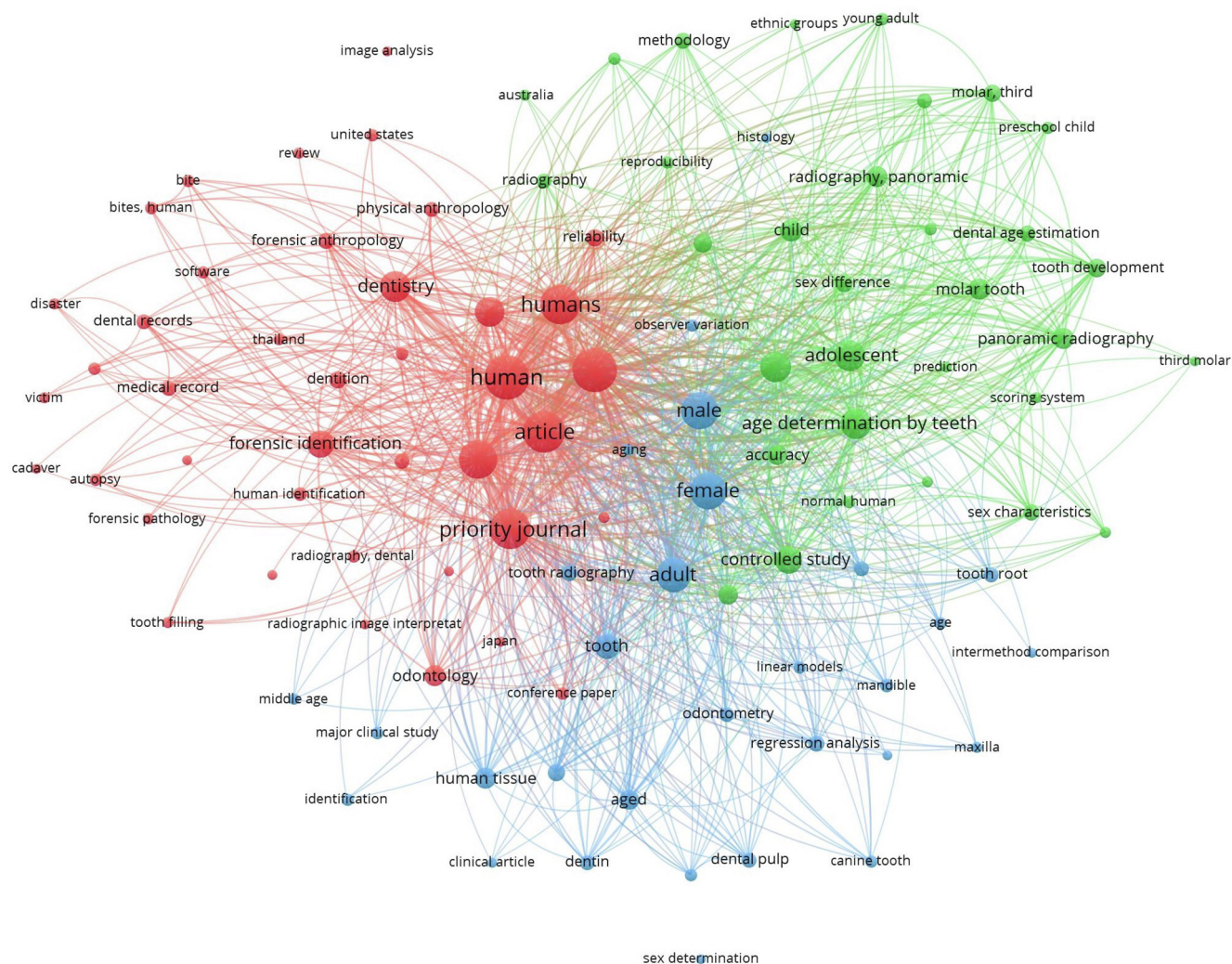


Fig. 3 Keywords co-occurrence network.

documents ($n = 16$) followed by the Università degli Studi di Macerata ($n = 6$), Universiteit Hasselt ($n = 5$), Università Politecnica delle Marche ($n = 5$) (Table 2).

3.6. Topic-wise analysis 100 best cited papers

Majority of the papers were related to age estimation (46) followed by victim identification (30), mass disaster (9), bite mark analysis (8), sex determination (5), race determination (4), dental DNA analysis (3), palatal rugae pattern (2) and lip prints (1). The details of topic wise bifurcations of the 100 best-cited papers are displayed in Table 4.

3.7. Keywords analysis

A total of 800 keywords were identified. “Human” appeared 90 times followed by “forensic odontology” (87), “forensic dentistry” (66), “age determination by teeth” (44) and “forensic identification” (33). A node size denotes the frequency of the keywords and the joining lines represent the total strength of the co-occurrence with other keywords (Fig. 3).

4. Discussion

In medical literature, one of the tools to recognize the most significant articles in a specific field is the citation analysis. Bibliometric tools are used by many researchers to explore the impact in the field; the impact of a set of researchers, the impact of a particular paper or to identify the specific impactful papers within a particular field of research. According to Heldwein et al., (2010) publications receiving 100 or more citations are designated as classic papers. Present study identified 6 papers that have achieved more than 100 citations and thus can be considered as classic. The knowledge and understanding of these classic papers helps young researchers, faculty members and students to keep themselves well-acquainted with classic knowledge. In the present analysis, 8.7% of the papers were considered as best cited papers in FO, which is comparable to the previous papers published in the literature on bibliometric analysis (Liu et al., 2015, Lai et al., 2017, Hui et al., 2013).

Field-normalized Journal Impact factors (JIFs) such as JIF quartiles have been introduced and increasingly adopted in

research evaluation due to incomparability across different research areas (Liu et al., 2016). Quartile rankings are calculated for each journal in each subject category according to which quartile of the journal occupies in the impact factor distribution of that subject category. The total number of publications and/or the share of total publications in a given quartile, usually first quartile (Q1), can play an important role in performance-based funding of public research (Garcia et al., 2012). In the present analysis, maximum journals and the papers were in quartile I (Journal: 9; papers: 60) and very less number of journals and papers were attributed to quartile II (Journal 3; papers 32) and III (Journals: 4; papers 8).

Authors usually opt for high-impact journals for their research publication and journals with high impact factors are interested in publication of high quality papers (Gondivkar et al., 2018a; Gondivkar et al., 2018b). This fact is proved by past bibliometric studies which have showed positive correlation between citation frequency and JIFs (Liu et al., 2015; Lai et al., 2017; Miranda and Garcia-Carpintero, 2019). No such correlation was reported in the present analysis. Nowadays, authors care more about the readership of the journal and hence believe in publishing their high end papers in specialty journals irrespective of the impact factors. Forensic Science International and Journal of Forensic Sciences have contributed 36 and 29 articles respectively though they are low impact factor journals. This shows that researchers refer these two journals more often for publishing papers on FO.

The decade 2000s was the most prolific one with 68 articles. This finding was in accordance with the observation from the previous study (Pena-Cristobal et al., 2018) Citation analysis is often criticized due to the impact of time. Older articles usually get ample time for receiving citations than the recently published papers regardless of their scientific value. Thus most recent influential articles would not reflect in such analysis. Moreover, some studies that have become landmark trials may achieve fewer citations over time because their results are so universally accepted that their source or contributors are often not remembered. This is known as “obliteration by incorporation” effect (Gupta et al., 2019). This could be the reason why articles of recent five years have not been included in the top 100 list. A quick access of the journals through web based electronic media in recent times might help researchers to get an insight into their respective fields. To rectify time bias, we calculated the citation density of each article, which brought forward their scientific impact, annually.

It is observed that nation with better economic rankings perform well at biomedical publications, in terms of both quality and quantity (Pena-Cristobal et al., 2018; Lai et al., 2017) European countries and the United States had maximum contribution to the 100 most cited articles on FO. This is in concurrence with Pena-Cristobal et al., 2018; Lai et al., 2017. It is worth mentioning that 10 of the papers originating from Italy and 9 papers from Denmark resulted from international collaborations. In respect of papers by individual authors, Williams G from Belgium was top in the list with 16 articles.

Review papers tend to be cited more frequently than regular research articles. It has been observed in the literature that average citations received by reviews depends largely on the research area considered, varying from 1.34 to 6.74 times the citations received by original research articles (Miranda and

Garcia-Carpintero, 2018). The present study had 6 review papers. The most cited document (citations: 259) was a review paper.

A topic-wise analysis was also performed. Majority of the studies were on age estimation (46) followed by victim identification (30). FO plays major role in victim identification in mass disasters (Prajapati et al., 2018; Sarode et al., 2009) and there were nine papers in the present analysis. Among various different modalities in FO, bite mark analysis is widely used in criminal investigations with 8 papers Lit prints analysis is less reliable technique due to various limitations and hence only one paper reflected in the 100 best-cited papers. In the present analysis, total of 800 keywords were identified. “Human” appeared 90 times followed by “forensic odontology” (87), “forensic dentistry” (66), “age determination by teeth” (44) and “forensic identification” (33). This keywords analysis is in coherent with the most commonly published topics e.g. for age estimation topic, “age determination by teeth” keywords appeared 44 times and in victim identification topic, keyword “forensic identification” appeared 33 times. Majority of the papers were original research papers (94) followed by review articles (6). None of the papers were in the category of case reports, editorials, correspondence and short communications.

In the present analysis, majority of the papers were published in the journal subject heading of Medicine (n = 84); Biochemistry, Genetics and Molecular Biology (n = 25); Dentistry (n = 11) followed by Social Sciences (n = 10; citations: 248; h index: 6). When comparing the most cited article published in very different research areas with very different expected citations can be a drawback of the analysis carried out. In tune with this, subject area Medicine (citations: 4113, h index: 47) and Biochemistry, Genetics and Molecular Biology (citations: 983; h index: 25) received maximum number of citation and h index. While social science received least number of citations (citation: 518; h index: 11). However, possibility of influence of number of papers in each subject category and research area consideration on number of citations could not be underestimated.

It is common practice to study the level of evidence of papers in bibliometric analysis in health science. They reflect the quality of study design, validity of results and applicability to the patient care. All the currently available scales are designed for the clinical studies; hence it was not possible to perform the level of evidence analysis for the publications included in the present study. However, a dire need has been raised for design and development of level of evidence scales for such kind of studies (Sarode et al., 2019).

The bibliometric analysis have certain inherent limitations. The citation analysis information was retrieved from Scopus Database. Hence, there is a possibility of exclusion of true “classic” articles available in other databases (Web of Science and PubMed, Google Scholar). Moreover, other databases might have different hierarchy for best-cited papers on FO. Still Scopus is considered as the most authentic database for the citation analysis and is used widely in the literature. Often it happens so, that through snowball effect, researchers incline to cite previous highly cited articles irrespective of content and quality (Kuhn, 1962). A bibliometric analysis quantifies the recognition of an article in a specific field but usually does not reflect its quality (Gondivkar et al., 2018a; Gondivkar

et al., 2018b). Time has a major impact on citation analysis wherein older articles have greater advantage than recent ones irrespective of their high scientific value. Even though there are limitations, the data provided in the current study do give an insight into the major research areas of FO.

5. Conclusion

This is the first of its kind citation analysis of the 100 most cited papers on FO. All articles were published in English language and majority of them appeared after the year 2001. Since, FO is a highly specialized subject, most of the articles were published in specialty journals. Authors from Belgium, United States and Italy contributed significantly to the top-cited articles. The top cited paper was a review article. We believe that the list of top 100 articles presented in the current study will definitely serve as an imperative source of information for researchers, academicians and students. This type of analysis will help the scientists to identify the noteworthy research areas in FO and gives future direction for the research.

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Ethical statement

The study does not involve trials involving experiments in humans.

CRediT authorship contribution statement

Namrata Sengupta: Data curation, Formal analysis, Investigation, Resources, Writing - original draft, Writing - review & editing. **Sachin C. Sarode:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Writing - original draft, Writing - review & editing. **Gargi S. Sarode:** Formal analysis, Methodology, Resources, Validation, Visualization, Writing - review & editing. **Amol R. Gadbail:** Resources, Validation, Visualization, Writing - review & editing. **Shailesh Gondivkar:** Resources, Validation, Visualization, Writing - review & editing. **Sneha Patil:** Data curation, Software, Writing - original draft, Writing - review & editing. **Shankargouda Patil:** Conceptualization, Supervision, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sdentj.2020.04.005>.

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