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Bibliometric Analysis of The 40 Years Literature On Vertebral Fractures With Science Mapping Method

Bilimsel Haritalama Yöntemiyle Vertebral Kırıklara İlişkin 40 yıllık Literatürün Bibliyometrik Analizi

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ABSTRACT

Each year, over 1.5 million individuals in the United States are diagnosed with vertebral compression fractures. The concept of bibliometrics pertains to the analysis of bibliographic data. The examination and visualization of the literature within a scientific discipline or its subcategories is referred to as science mapping. This study represents a comprehensive analysis of the literature on vertebral fractures. In our research, the Web of Science database was utilized for analyses, encompassing the period from 1980 to 2022. The analyses were divided into four categories: performance analysis, keyword analysis, thematic analysis, and co-citation network analysis. Word Cloud, Frequency Table, Trend Topics, and Co-occurrence Networks were examined. Thematic Maps and Thematic Evolution Maps were also constructed. Furthermore, a co-citation network analysis of articles was conducted. The analyzed articles were authored by 9,020 researchers. The annual increase in the number of publications was recorded as 9.54%. The average number of citations per document was 44.05. Approximately 18.7% of the articles were published through international collaborations, with Europe standing out prominently in this regard. Genant HK was identified as the author with the highest h- and g-indices. The most active institution was the University of California, San Francisco. The most frequently used keywords included Vertebral Fracture, Osteoporosis, and Bone Mineral Density. Over the past 40 years, the scientific literature on spinal fractures has been analyzed through science mapping. The developmental dynamics of this field have been identified.

Key Words: Bibliometrics, Science Mapping, Vertebral Fractures, Web of Science.

ÖZ

Amerika Birleşik Devletleri'nde her yıl 1,5 milyondan fazla kişiye vertebral kompresyon kırığı tanısı konmaktadır. Bibliyometri kavramı bibliyografik verilerin incelenmesidir. Bir bilimsel disiplinin veya onun alt kategorisine ait literatürün analizi ve görselleştirilmesi bilim haritalaması olarak tanımlanmaktadır. Bu çalışma vertebra kırıkları ile ilgili literatürün kapsamlı bir analizidir. Araştırmamızda analizler için Web of Science kullanılmıştır. Çalışmamız 1980'den 2022'ye kadar olan zaman dilimini kapsamaktadır. Analizler; performans, anahtar kelime, tematik ve ortak atıf ağı analizleri olmak üzere dört bölümden oluşmaktadır. Kelime Bulutu ve Frekans Tablosu, Trend Konuları ve Birlikte Oluşum Ağı analiz edilmiştir. Tematik Harita ve Tematik Gelişim Haritası oluşturulmuştur. Makale Ortak Alıntı Ağı analizi gerçekleştirilmiştir. Analiz edilen makaleler 9.020 yazar tarafından yazılmıştır. Makale sayısındaki yıllık artış ise %9,54 oldu. Belge başına ortalama alıntı sayısı 44,05'tir. Makalelerin yaklaşık %18,7'si uluslararası işbirliği yoluyla yayınlanmıştır. Uluslararası işbirliği açısından Avrupa özellikle öne çıkıyor. Genant HK en yüksek h ve g-indeksine sahip yazardır. En aktif kurum San Francisco'daki Kaliforniya Üniversitesi'dir. En çok tekrarlanan anahtar kelimeler Vertebral Kırık, Osteoporoz, Kemik Mineral Yoğunluğu'dur. Omurga kırıklarına ilişkin son 40 yıllık literatür bilimsel haritalamayla analiz edilmiştir. Konunun gelişim dinamikleri belirlenmiştir.

Anahtar Kelimeler: Bibliyometri, Bilim Haritalaması, Vertebral Kırıklar, Web of Science.

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Introduction

The vertebrae, which consist of 33 vertebrae, protect the spinal cord and provide axial support to the limbs. While vertebral fractures can arise from trauma, infection, and metastatic disease, the most common cause is osteoporosis [1].

The most common precipitating factor for vertebral fractures is osteoporosis. However, trauma, chemotherapy, and steroid use can also lead to compression fractures. Smoking, alcohol, and low estrogen levels are associated with the etiology of low bone density. Trauma is the second most frequent cause of vertebral fractures [2].

It is estimated that there are over 200 million osteoporosis patients worldwide [3], with 30% of women being affected by osteoporosis [2]. In the United States, more than 1.5 million people are diagnosed with vertebral compression fractures each year [2,3]. The frequency of these fractures is 10.7 per thousand in women and 5.7 per thousand in men. Traumatic vertebral fractures are more commonly seen in men around the age of 30, with an incidence of 160,000 cases each year. These fractures can cause pain, decrease quality of life, and lead to social isolation [4].

The concept of bibliometrics is the examination of bibliographic data. Bibliometrics has two pillars: performance analysis, which is measurable through article and citation counts, various indices, and scientific mapping. The analysis and visualization of the literature of a scientific discipline or its subcategory is defined as science mapping [5]. Bibliometrics is an interdisciplinary field involving the quantitative analysis of academic literature, facilitating the evaluation of research output and impact through statistical methods. In medicine, bibliometrics plays a pivotal role in tracking the dissemination of knowledge, evaluating the performance of researchers, and guiding decision-making in academic and clinical practice [5].

Science mapping is generally used to determine the evolution of academic knowledge, multidisciplinary connections, and research trends [6]. Science mapping is utilized to fund scientific research and strategic planning. This method guides policies related to the academic field. It benefits interaction between researchers and across scientific areas. In today's world, the volume of scientific literature has reached a vast extent and continues to grow. This makes it increasingly difficult for researchers to keep track of developments. At this stage, bibliometric analysis intervenes, rendering the extensive literature manageable and providing a qualified projection [7].

Bibliometric studies on vertebral fractures are limited in number [8,9]. Therefore, it has been determined that such a study is needed. This study is a comprehensive reviewing analysis of the literature on vertebral fractures. It aims to analyze research on vertebral fractures, obtaining information that will guide future research on vertebral fractures.

Methods of Research and Analysis:

Research Strategy: Our study's flowchart of data collection, data analysis, and data visualization is in Figure 1 A.Our research utilized the Web of Science (WoS), with analyses and scans conducted on this platform on November 20, 2023. Our study encompasses the time frame from 1980 to 2022. The search incorporated the keywords "Vertebral Fractures" and "Vertebral Fracture." Article types, excluding Research and Review Articles, were omitted. The language preference was set to "English." The scope of WoS was confined to the SCI, SCI-E, and SSCI indices. Clarivate Analytics' Web of Science Core Collection comprises eight databases. Only SCI, SCI-E, and SSCI are utilized due to their indexing of the most significant sources related to the subject under investigation. The year 2023 was excluded from the scope owing to the year needing to be completed at the time of the study. Ultimately, the analyses were performed with 2187 articles.

The analyses comprised four sections: performance, keyword, thematic, and co-citation network analyses. These analyses consolidated terms, combining "Vertebral Fractures" with "Vertebral Fracture."

Performance Analysis: An extensive evaluation has been conducted encompassing Main Information on Publications, delineating the volume and impact of scholarly works and their citations over time. This includes meticulously

analyzing the Corresponding Author's Nationality, the influence exerted by authors and sources, and identifying prominently cited local articles. Additionally, intricate relationships among authors, keywords, sources, and the dynamics within Institutional Collaboration Networks have been scrutinized.

Analyzing the main information on publications has established a detailed elucidation of Author Collaboration. This segment offers statistical insights into the Annual Growth rate, the mean lifespan of documents (Document Average Age), and the average number of citations per document.

In dissecting the Corresponding Author's Country, total, single, and multiple country publications (TCP, SCP, and MCP) have been computed alongside the MCP Ratio (MCP/TCP).

The analyses concerning Author Impact and Source Local Impact encompass sophisticated metrics like the h-index, g-index, m-index, number of publications (NP), total citations (TC), citations per publication (TC/NP), and the inception year of publication (PY-start).

The Most Local Cited Articles analysis has computed variables such as Year of Publication (YP), 2023-Year of Publication (YYP), Global Citations (GC), and Local Citations (LC), along with ratios adjusted for temporal influence, including LC/YYP, GC/YYP, and the LC/GC Ratio%. Here, LC denotes the count of citations made by articles within the dataset, while GC represents citations from articles indexed in the Web of Science database.

The interconnections between authors, keywords, and sources have been analytically explored using Sankey diagrams, illustrating the flows and transitions among these entities.

Lastly, in the Institutions Collaboration Network analysis, clusters of institutions have emerged, with each circle within the clusters representing a distinct institution. The size of these circles is proportional to the level of collaboration of the institution, and the thickness of the lines between circles correlates with the degree of collaboration between institutions.

Keyword Analysis: In our study, two types of keywords were utilized in the databases: those added by the author and those generated by the system. Only the keywords provided by the author were employed in the analyses. Word Cloud and Frequency Table, Trend Topics, and Co-Occurrence Network have been analyzed. In the Word Cloud and Frequency Table analyses, the top 50 keywords used in the articles were employed. The Trend Topic analysis reveals the years in which these keywords became popular. For each year, the first two keywords used at least five times have been visualized in the analysis. In the Co-Occurrence Network analysis, the keywords formed clusters represented by different colors. Each circle within these clusters represents a keyword, and the most frequently used keyword within a cluster denotes its representative keyword.

Thematic Analysis: A Thematic Map and a Thematic Evolution Map have been created. The Thematic Map (Strategic Diagram) was constructed using the first 250 keywords repeated at least five times. The research period (1980-2022) has been divided into distinct eras, considering the number of documents for thematic examination. The first period spans 28 years (1980-2007), the second period covers seven years (2008-2014), the third period is five years (2015-2019), and the fourth period is three years (2020-2022).

The most frequently repeated keywords are grouped into thematic clusters. The three most recurring keywords represent each cluster. The size of the circles is proportional to the frequency of use of the keyword represented by the circle. Two parameters, centrality on the X-axis and density on the Y-axis, have been determined to form the Thematic Map. Centrality indicates the importance of the theme, while density represents its development. The X-axis and the Y-axis have been divided into four quadrants to represent themes. In the top right corner of the thematic map are Motor Themes, in the top left corner are Niche Themes, in the bottom left corner are Emerging or Declining Themes, and in the bottom right corner are Basic Themes.

A thematic evolution map has been additionally created to examine the changes and developments in themes over the years. In the evolution map, the size of the nodes indicates the abundance of

keywords, while the flow lines between the nodes represent the direction of evolution of the thematic clusters.

Co-Citation Network: A paper co-citation network analysis was conducted to examine common citations. The top 30 publications were analyzed. The common citations formed clusters represented by different colors. Each circle within these clusters represents an individual article. The circle size correlates with the number of citations received, while the thickness of the lines between the circles is proportional to the citation relationship among the articles. Data from the Web of Science (WoS) database has been utilized for the Co-Citation Network analysis. All the articles are available within the WoS database.

Results of Comprehensive Review

Performance Analysis: Table 1 presents the performance analysis results. The annual increase in the number of articles is 9.54%.

Figure 1 B presents the annual number of articles and citations. According to the table, the number of articles has been increasing steadily. The number of citations also increased regularly until the early 2000s. Subsequently, it entered a decreasing trend and has fluctuated at a certain level.

Figure 1 C presents the countries of the authors of the analyzed articles. The authors are ranked according to the total number of articles published. The United States (USA) leads with 357 articles, boasting the highest number of publications and MCP-Ratio with 70 articles. Japan has published 305 articles, yet its MCP ratio is relatively low. In terms of international collaboration, Europe is notably prominent. Countries like the United Kingdom, Germany, and the Netherlands exhibit high MCP ratios.

Table 2 lists the first 20 authors according to their h-index values. Genant HK has the highest h and g-index. Cummings SR and Kanis JA are second and third regarding the h-index, respectively. Mazziotti G has the highest m-index value.

Table 3 displays the top 20 sources ranked according to their h-index values. 51.12% of the articles included in the analysis were published in these sources. Osteoporosis International's h-index value is 71. Despite its high h-index value, its TC/NP (Total Citations per Number of Publications) value is average. Regarding the TC/NP value, the Archives of Internal Medicine stands out among others. The journal Archives of Osteoporosis, which started its publication life in 2015, has quickly become influential.

Table 4 lists the top 20 publications with the most citations according to their LC values. The 1993 article by Genant HK has the highest LC value. Following this are the articles by Lindsay R. from 2001 and Cooper C. from 1992. The publication with the highest GC value is the 1996 article by Black DM. The 2006 article by Schousboe JT is more recent than the others. Nevertheless, it has become influential in a short time.

Figure 1 D illustrates the relationships among authors, keywords, and sources. The results of the analysis of inter-institutional collaboration are presented in Figure 2 A. A network of 30 nodes was established employing the Walktrap Algorithm. Each node represents an institution, which has formed eight clusters.

The University of California, San Francisco, is the most active institution regarding collaborative activity, located in the blue cluster. McMaster University, the University of British Columbia, and the University of Toronto follow this. The most intensive collaboration and interaction are observed in the red cluster.

Keyword Analysis: Figure 2 B presents the most frequently used keywords as a word cloud and a frequency table, with the top 50 shown. The most recurrent keywords include Vertebral Fracture, Osteoporosis, Bone Mineral Density, Vertebroplasty, Kyphoplasty, and Epidemiology. According to trend topic analysis, researchers today focus on artificial intelligence and deep learning (Figure 2 C).

In Figure 2 D, the co-occurrence network of keywords is presented. The keywords have been clustered into four groups. The red cluster represents the keywords for osteoporosis, the blue cluster for Vertebroplasty, the green cluster for Fracture, and the purple cluster for Vertebral Fracture Assessment.

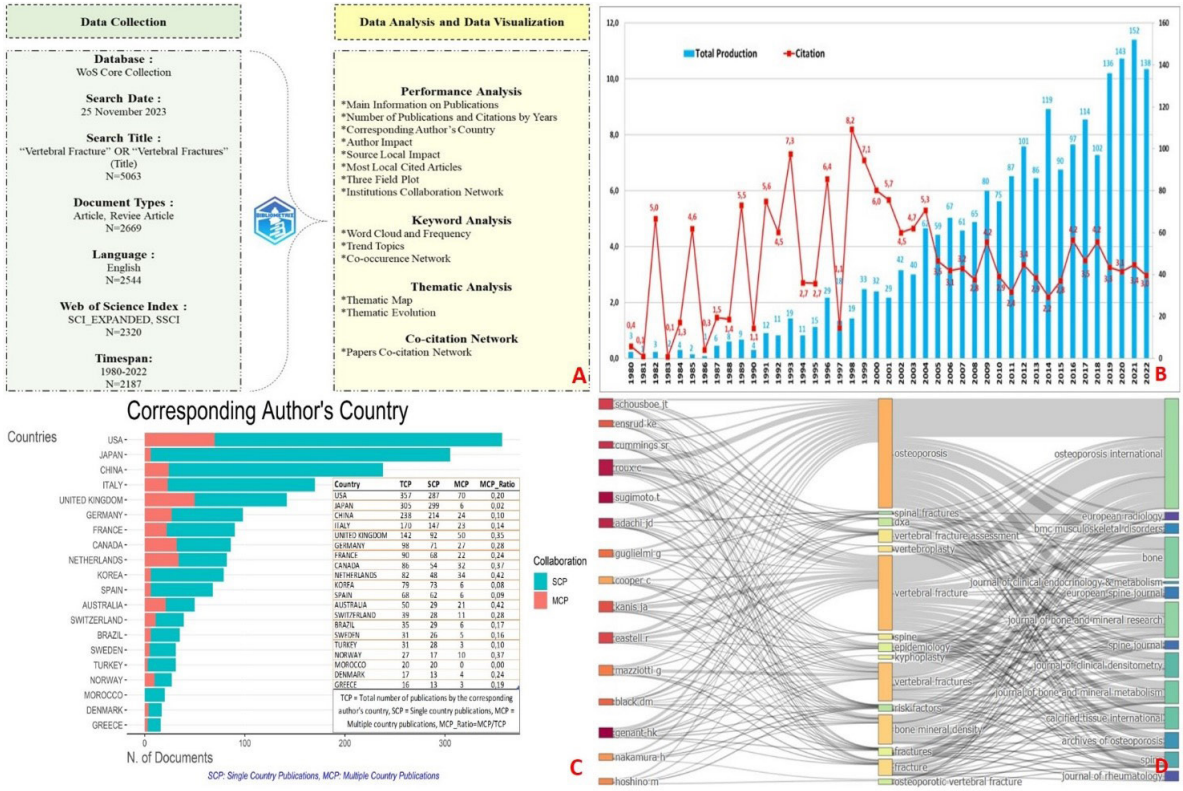

Figure 1. A. Flowchart of Data Collection, Data Analysis and Data Visualization, B. Number of Publications and Citations by Years, C. Corresponding Author's Country, D. Relationship between Authors (left), Keywords (middle) and Sources (right).

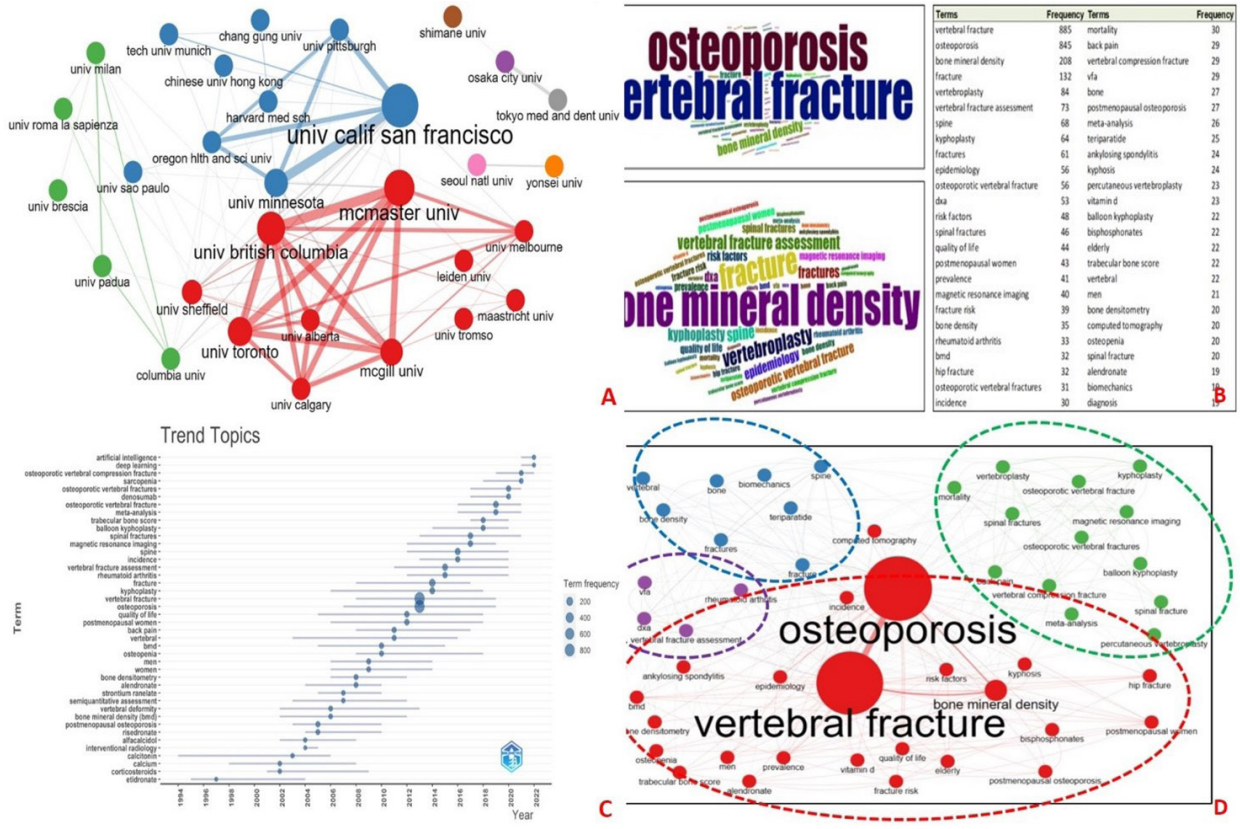

Figure 2. A. Institutions Collaboration Network. The size of these circles is proportional to the level of collaboration of the institution, and the thickness of the lines between circles correlates with the degree of collaboration between institutions. B. Word Cloud and Frequency Table, C. Trend Topics, D. Co-Occurrence Network. The size of these circles is proportional to the level of Co-Occurrence, and the thickness of the lines between circles correlates with the degree of Co-Occurrence.

Table 1. Performance Analysis Results and Main Information

Description	Results	Description	Results
MAIN INFORMATION ABOUT DATA		AUTHORS	
Timespan	1980:2022	Authors	9020
Sources	484	Authors of Single-Authored Docs	43
Documents	2187	AUTHORS COLLABORATION	
Annual Growth Rate %	9,54	Single-Authored Docs	46
Document Average Age	11,3	Co-Authors per Doc	7,35
Average Citations per doc	44,05	International Co-Authorships %	18,7
References	32743	DOCUMENT TYPES	
DOCUMENT CONTENTS		Article	2003
Keywords Plus (ID)	2755	Article; Early Access	2
Author's Keywords (DE)	2819	Article; Proceedings Paper	56
		Review	126

Table 2. Author Impact

Author	h_index	g_index	m_index	TC	NP	PY_start
Genant HK	36	47	0,923	16673	47	1985
Cummings SR	29	36	0,829	13507	36	1989
Kanis JA	29	32	0,935	3809	32	1993
Eastell R	28	32	0,8	5821	32	1989
Black DM	26	29	0,743	11323	29	1989
Roux C	25	40	1,042	4702	40	2000
Ensrud KE	24	31	0,857	7935	31	1996
Sugimoto T	24	45	1,043	2059	45	2001
Adachi JD	23	36	0,742	2983	36	1993
Cooper C	22	26	0,688	5914	26	1992
Yamauchi M	21	25	0,913	1553	25	2001
Delmas PD	20	22	0,8	5886	22	1999
Felsenberg D	20	21	0,69	3674	21	1995
Giustina A	20	26	1,111	1280	26	2006
Schousboe JT	20	33	1,053	1359	33	2005
Yamaguchi T	19	22	0,826	1486	22	2001
Mazziotti G	18	29	1,125	995	29	2008
Guglielmi G	17	29	0,773	1233	29	2002
Johnell O	17	18	0,472	2619	18	1988
Siminoski K	17	23	0,81	1094	23	2003

NP = Number of publications, TC = Total citations, PY_start = Publication year starting.

Thematic Analysis: The Thematic Map for 2020-2022 is presented in Figure 3 A. Our research focal point from 2020 to 2022 encompasses basic themes such as Osteoporosis-Vertebral Fracture, Osteoporotic Vertebral Fracture-Kyphoplasty, and Fracture-Vertebral Fracture Assessment. Figure 3B displays the Thematic Evolution Map. According to this map, osteoporosis is the predominant theme during the 2020-2022 period. In addition, themes such as Hip Fracture, Osteoporotic Vertebral Fracture, and Spine have emerged.

Co-Citation Network Analysis: Figure 3 C depicts the results of the paper co-citation network analysis. Three clusters have formed, each distinguished by different colors. The red cluster comprises articles such as "Genant HK 1993, O'Neill TW 1996, and Melton LJ 1989." The blue cluster includes papers like "Lindsay R. 2001, Cooper C 1992, and Black DM 1999." The green cluster contains articles like "Black DM 1996, Ettinger B 1999, and Harris ST 1999."

Table 3. Source Local Impact

Source	H Index	G Index	M Index	TC	NP	TC/NP	PY start
Osteoporosis International	71	112	2,219	16258	308	52,79	1992
Journal of Bone and Mineral research	65	127	1,757	16272	135	120,5	1987
Bone	42	77	1,077	6216	111	56,00	1985
Calcified Tissue International	30	52	0,833	2837	62	45,76	1988
J of Clinical Endocrinology & Metabolism	29	47	0,806	3213	47	68,36	1988
SPINE	26	49	0,765	2460	55	44,73	1990
Journal of Clinical Densitometry	21	38	0,875	1593	61	26,11	2000
European Spine Journal	20	34	0,909	1222	38	32,16	2002
Journal of Bone and Mineral Metabolism	19	31	0,731	1153	67	17,21	1998
Journal of Rheumatology	17	22	0,63	731	22	33,23	1997
Bmc Musculoskeletal Disorders	15	26	0,682	728	41	17,76	2002
European Journal of Endocrinology	13	15	0,684	636	15	42,40	2005
European Radiology	13	20	0,684	477	20	23,85	2005
Spine Journal	13	18	1	391	28	13,96	2011
Archives of Osteoporosis	12	16	1,333	386	46	8,39	2015
Endocrine	11	16	0,733	385	16	24,06	2009
Rheumatology	11	14	0,458	535	14	38,21	2000
American Journal of Medicine	10	10	0,417	1265	10	126,5	2000
American Journal of Neuroradiology	10	12	0,417	504	12	42,00	2000
Archives of Internal Medicine	10	10	0,27	2418	10	241,8	1987

Table 4. Most Local Cited Articles

Document	YP	LC	LC/YYP	GC	GC/YYP	LC/GC Ratio%
Genant hk, 1993, J Bone Miner Res	1993	712	23,733	2618	87,267	27,20
Lindsay r, 2001, Jama-J Am Med Assoc	2001	284	12,909	1228	55,818	23,13
Cooper c, 1992, J Bone Miner Res	1992	245	7,903	1077	34,742	22,75
Genant hk, 1996, J Bone Miner Res	1996	212	7,852	502	18,593	42,23
Kado dm, 1999, Arch Intern Med	1999	176	7,333	757	31,542	23,25
Nevitt mc, 1998, Ann Intern Med	1998	173	6,920	617	24,680	28,04
Ross pd, 1991, Ann Intern Med	1991	168	5,250	890	27,813	18,88
Melton lj, 1989, Am J Epidemiol	1989	141	4,147	742	21,824	19,00
Delmas pd, 2003, Bone	2003	138	6,900	394	19,700	35,03
Delmas pd, 2005, J Bone Miner Res	2005	138	7,667	385	21,389	35,84
Black dm, 1996, Lancet	1996	125	4,630	2931	108,556	4,26
Eastell r, 1991, J Bone Miner Res	1991	119	3,719	502	15,688	23,71
Melton lj, 1999, Osteoporosis Int	1999	106	4,417	374	15,583	28,34
Jiang g, 2004, Osteoporosis Int	2004	103	5,421	207	10,895	49,76
Ettinger b, 1999, Jama-J Am Med Assoc	1999	99	4,125	2428	101,167	4,08
Gehlbach sh, 2000, Osteoporosis Int	2000	99	4,304	280	12,174	35,36
Felsenberg d, 2002, J Bone Miner Res	2002	95	4,524	477	22,714	19,92
Oleksik a, 2000, J Bone Miner Res-a	2000	90	3,913	385	16,739	23,38
Schousboe jt, 2006, Osteoporosis I.	2006	78	4,588	139	8,176	56,12
V. Der klift m, 2002, J Bone Miner Res	2002	76	3,619	222	10,571	34,23

Year of Publication (YP), YYP= Year 2023-Year of Publication, Global Citations (GC), Local Citations (LC)

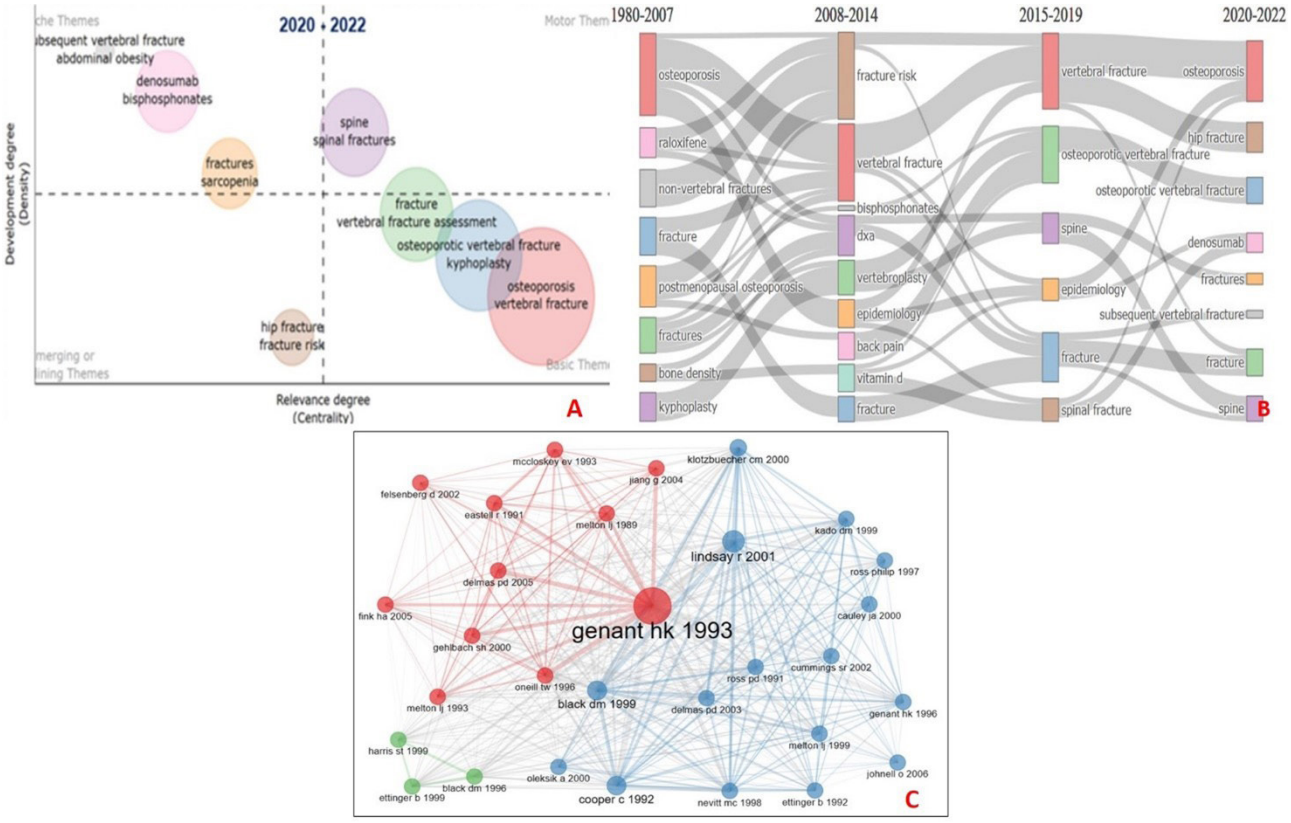

Figure 3. A. Thematic Map. The size of the circles is proportional to the usage level of the keyword. B. Thematic Evolution (1980–2022). The thickness of the lines correlates with the frequency of the keyword usage. C. Papers Co-Citation Network. The size of these circles is proportional to the level of Co-Citation, and the thickness of the lines between circles correlates with the degree of Co-Citation between papers

Discussion:

Science mapping is a multifaceted domain within the broader scope of scientometrics, primarily concerned with the systematic and quantitative analysis of scientific literature. Its primary objective is to uncover scientific research's intricate structural and dynamic patterns. This endeavor involves meticulously examining various elements such as citations, authorship, co-authorship networks, and keyword frequencies [10]. At its core, science mapping leverages sophisticated methodologies and algorithms to visualize the landscape of scientific fields. This analytical approach is not only instrumental in understanding the evolution of scientific disciplines but also aids in identifying interdisciplinary connections and potential areas for future research [8].

Furthermore, science mapping is crucial in policy-making and strategic planning for research institutions and funding bodies. A comprehensive overview of the scientific terrain enables stakeholders to make informed decisions about resource allocation, collaboration opportunities, and research directions [7].

Eugene Garfield, a notable figure in scientometrics, has made significant contributions to this area. He developed the widely used academic resource, the WoS, an expansive dataset and a continually growing international database. Its characteristics make it the most effective data source for bibliometric analyses. The utilization of WoS in our study is of utmost importance for the reliability of our data [11,12].

The Bibliometrix program we employed is based on R, an open-source software. The R language is used in a wide range of studies, including medicine, and its primary feature is the production of visual data, especially graphics. This enhances comprehensibility. Our study has been enriched with these detailed graphics [10].

In the published article, the United States and Canada stand prominently. Both nations exhibit high MCP values, with Canada particularly noteworthy for its collaborative efforts. European countries have made significant contributions to

Vertebral Fracture, with nations like the United Kingdom, Germany, the Netherlands, and Switzerland demonstrating high MCP values, indicative of their leadership in global collaboration. In Asia, the contributions of Japan, China, and Korea are notable. These countries tend to favor internal collaboration, though China's MCP value surpasses the others. Overall, Europe and North America are leading in international collaboration.

The h-index, conceived by physicist Jorge E. Hirsch in 2005, represents a unique metric designed to quantify the cumulative impact and relevance of an individual scientist's research output [13]. An h-index of 'n' implies that a researcher has authored 'n' papers, each of which has been cited in other scholarly works at least 'n' times. This index mitigates the disproportionate weight given to a few highly cited papers or the mere quantity of publications, thus offering a more balanced and comprehensive evaluation of a researcher's contributions [14]. The h-index also provides a robust framework for comparing scholarly influence across disciplines. It may undervalue the contributions of early-career scientists. Furthermore, it must account for the context or nature of citations, potentially overlooking the nuance in the citation landscape [13,14].

The g-index was conceived to address certain limitations inherent in the h-index and developed by Leo Egghe in 2006. The g-index aims to provide a more nuanced reflection of a researcher's scholarly influence. At its core, the g-index asserts that a researcher's top g articles have, collectively, garnered at least g^2 citations [14]. This metric furnishes a more comprehensive appraisal of a researcher's contribution to their field. Developed as a derivative of the h-index, the m-index provides a more time-sensitive analysis by accounting for the duration of an individual's active research career. The m-index is calculated by dividing the h-index of a researcher by the number of years since their first published paper. This approach offers a more equitable comparison between early-stage researchers and those with more extended careers. The m-index should be employed with other measures to assess a researcher's impact holistically [15].

Professor Harry K. Genant, a renowned figure in radiology, passed away in 2021. He is the editor or author of over 40 books and over 600 scholarly articles [16].

The journal Osteoporosis International boasts the highest scores in terms of h, g, and m-index, as well as NP Number of Publications and TC Total Citations. This publication enjoys a broad impact and citation reach. Osteoporosis International is a multidisciplinary journal published by the International Osteoporosis Foundation and the USA National Osteoporosis Foundation [17].

Following "Osteoporosis International" in terms of h-index is the "Journal of Bone and Mineral Research," published by the American Society for Bone and Mineral Research. However, when considering TC/NP, which represents the average number of citations per article, the "Journal of Bone and Mineral Research" takes a leading position. This indicates that the articles in this journal receive more citations, underlining their significant presence in the literature [18].

The Genant HK 1993 article pertains to the criteria for assessing vertebral fractures using conventional radiography [19]. Lindsay R's 2001 publication focuses on the frequency of recurrent vertebral fractures within the same year. It is a multicenter study involving approximately 5000 participants [20]. The 1996 article by Black DM investigated the effect of alendronate on fracture risk in postmenopausal women with low bone mass [21]. The 2006 paper by Schousboe JT calculated the cost per Quality-Adjusted Life Year QALY for oral bisphosphonate therapy in menopausal osteopenia [22].

The relationship among authors, keywords, and sources was examined. For this purpose, a Sankey diagram or data visualization technique was utilized. Sankey diagrams emphasize the flow, movement, or change from one state or time to another, illustrating the significance and generalizability of the study. Sankey diagrams can visualize processes and interactions [23]. The nodes in the diagram are rectangular, and the size of each node and the width of the lines between nodes are proportional to the number of members. Roux C, Kanis JA, Sugimoto T, and Mazziotti G frequently use keywords like osteoporosis, vertebrae fracture, and bone mineral density.

These authors have published their works in Osteoporosis International, Bone, and the Journal of Bone and Mineral Research [24–27].

In the Institutions Collaboration Network analysis, 30 nodes were based, and the Walktrap Algorithm was applied. Each node represents an institution. The institution with the most publications in terms of collaboration is the University of California San Francisco, followed by McMaster Univ, the University of British Columbia, and the University of Toronto. The thick lines between them indicate that the most frequent collaborations are between the California San Francisco -, Minnesota, Mcmaster Univ - of Univ British Columbia, and Mcmaster Univ - of Univ Toronto.

Keywords define and represent articles, identifying current topics and themes in the field of study through analyses utilizing these terms. Word cloud analysis facilitates the identification of intermingled fields and eases the analysis of keywords prevalent in these fields over the years [20].

The ten most frequent keywords encompass crucial terms related to vertebral fractures. These terms represent focal points of the subject and are associated with aspects such as the definition, assessment, treatment, and epidemiology of vertebral fractures.

Between 1994 and 2004, keywords like Etidronate, Corticosteroids, Calcitonin, and Alfacalcidol were prominent, reflecting significant treatment methods or assessment parameters relevant to the research of that era.

In contrast, contemporary research reveals a shift in focus. Terms like Artificial Intelligence, Deep Learning, and Denosumab have become trendy, indicating increased scrutiny of these technologies and novel treatment approaches. Keywords co-occurrence networks are utilized in scientific mapping studies. In these networks, each keyword is a node, and the co-occurrence of a pair of terms in a single article represents a link. The frequency of co-occurrence across multiple articles determines the strength of the link. Such networks represent cumulative knowledge in the field, and insights can be derived based on the strength of connections between key terms. Co-occurrence network-based analyses provide a rapid avenue for uncovering vast amounts of literature-related data [28]. According to the results of the keyword co-occurrence analysis conducted in our research:

The cluster represented by the keyword 'Osteoporosis' focuses on bone health, osteoporosis, and related subjects. It addresses research and review-oriented topics like bone mineral density, epidemiology, and risk factors and includes various treatment and assessment methods. It targets different populations, such as postmenopausal women and older individuals.

The cluster represented by 'Fracture' encompasses imaging techniques focusing on osteoporotic vertebral fractures and includes aspects related to mortality and pain. It also covers review approaches like meta-analysis.The cluster represented by 'Vertebroplasty' includes topics like Vertebral Fractures and Biomechanics, terms such as Spine and Bone Density, and mentions Teriparatide, a treatment for osteoporosis. It emphasizes treatment methods, with the term 'Biomechanics' addressing the formation of fractures and bone health from a biomechanical perspective.

The 'Vertebral Fracture Assessment' cluster concentrates on vertebral health and fracture assessment, indicating measurement and evaluation techniques. It highlights advanced imaging techniques used in these assessments. Vertebral fractures are clinically silent in approximately 65-75% of cases. Only 30-40% of these cases seek medical assistance [29]. Additionally, radiologists often encounter challenges in diagnosing these fractures accurately. Some studies have revealed that while the prevalence of vertebral fractures is around 29%, only a third of these cases are reported by radiologists [30]. This discrepancy highlights the need for improved diagnostic approaches in identifying vertebral fractures. In the diagnosis of vertebral fractures, diagnostic approaches such as Artificial Intelligence and Deep Learning are increasingly being investigated [31,32]. Consequently, their usage as key terms has escalated in recent years.

Denosumab, an inhibitor of osteoclast-mediated

bone resorption, reduces the risk of vertebral fractures [33,34]. Its usage has proliferated in the past decade, elevating Denosumab to prominence among keywords in this field.

Creating a Thematic Map has been accomplished using the first 250 keywords repeated at least five times, with the most frequently recurring keywords grouped into thematic clusters. In Thematic Map analyses, research themes are visualized across multiple periods, enabling the identification of research dynamics [35]. The Thematic Map reflects the interactions of the elements within the examined field of science over time, serving as a static description of the field's network structure [35].

The Thematic Map is divided into four quadrants, each representing different themes. Each quadrant is interpreted in its context. For this purpose, two parameters have been determined, encompassing centrality and density. The density parameter is represented along the y-axis, while the centrality parameter is represented along the x-axis, depicting the thematic map. The more central a chosen theme is, the more significant it is deemed, and the denser it is, the more it is considered to have completed its development [36].

Thematic Maps identify four different themes based on the x and y axes. Motor themes are considered developed themes and are essential in structuring research topics. Niche themes are those with limited interest. Emerging or declining themes are at a low level of development, while Basic themes are significant in interdisciplinary research topics.

Our study has certain limitations. One notable constraint is that the data were exclusively obtained from the WoS database. Incorporating data from additional databases could enrich the study.

In conclusion; using the bibliometric method, our study is a rare analysis of vertebral fractures. Thus, it is highly unique. This is likely an essential resource for policy formulation and strategic planning for research institutions and funding organizations. The findings of this study will serve as a fundamental tool in the academic analysis of research on vertebral fractures. By quantifying citations and collaboration networks, the study outputs offer a systematic evaluation of scientific productivity and the dissemination of knowledge. However, while metrics such as the h-index and impact factor provide valuable insights, they may only sometimes fully reflect the quality or significance of individual contributions. Therefore, they should be interpreted with caution. Moreover, the increasing reliance on quantitative metrics in academic assessment necessitates the development of more detailed and comprehensive approaches that integrate qualitative evaluations. As scientometrics continues to evolve, its role in shaping research policies, funding decisions, and advancing scientific knowledge will undoubtedly become increasingly significant.

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List of abbreviations:

- WoS : Web of Science
- YP: Year of Publication
- LC: Local Citations
- GC: Global Citations
- YYP: Year 2022-Year of Publication
- LC/YYP: Annual Local Citations

- GC/YYP: Annual Global Citations
- TC: Total Citations
- NP: Total Number of Publications
- TC/NP: Citations per paper
- PY_start: Publication year starting
- TPC: Total number of publications by the corresponding author's country,
- SCP: Single country publications,
- MCP: Multiple country publications,
- MCP_Ratio: MCP/TCP

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