www.jcrph.com
Journal of Cancer Research and Pharmacology. 2025; 1(1): 12-26
https://doi.org/10.22034/jcrph.2025.229250

Research Article Open Access

Global Research Trends in Iliac Crest Grafts for Maxillofacial Reconstruction: A Comprehensive Bibliometric Analysis

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Received: 27 July 2025 **Revised:** 26 August 2025 **Accepted:** 10 September 2025 **e-Published:** 15 September 2025

Abstract

Background and Aims: Iliac crest bone grafting is a cornerstone of maxillofacial reconstruction. This study provides a comprehensive bibliometric analysis of the global research trends, key contributors, and emerging themes in this field over the past three decades.

Methods: A systematic search of the Web of Science database was conducted for publications from 1990 to 2024. Data on publications, citations, authors, institutions, and keywords were extracted and analyzed using the Bibliometrix R package and VOSviewer for science mapping.

Results: The analysis included 2,512 publications. The field grew steadily at 2.35% annually. The most influential journals were the *Journal of Oral and Maxillofacial Surgery* and *Plastic and Reconstructive Surgery*. Leading authors included Urken, ML and Raghoebar, GM, while Mount Sinai Medical Center and UCLA were top institutions. The USA, Germany, and China dominated research output. Keyword analysis identified core themes like "iliac crest," "dental implants," and "mandibular reconstruction," with emerging trends in tissue engineering and regenerative medicine.

Conclusion: Research on iliac crest grafts for maxillofacial reconstruction is robust and evolving. The field is increasingly globalized and collaborative, with a clear shift towards innovative techniques like 3D printing and stem cell applications to improve patient outcomes and reduce morbidity. This analysis maps the intellectual landscape to guide future research directions.

Keywords: Iliac crest, Hip graft, Maxillofacial reconstruction, Bibliometric, Research trend.

1. Introduction

Autologous bone remains the gold standard in bone grafting for bone deficiency because of its inherent properties of osteo-conduction, osteo-induction, and osteogenesis. As it is histo-compatible and non-immunogenic, autologous bone finds extensive use in most of the surgical procedures for enhancing bone defects. One of its common uses is in maxilla or mandible reconstruction as a stable platform for implantation. One of the most common donor sites used in reconstructing large defects is the anterior iliac crest. Other donor sites, such as skull calvarial bone, are also utilized in certain instances. The iliac crest is the most commonly utilized donor site due to the relative ease with which it can be harvested, as well as its ability to provide a large quantity of cortical and cancellous bone.[1,2] Additionally, in a two-team surgical approach, concurrent bone harvesting can be integrated with the augmentation procedure, thus decreasing overall operative time. However, a significant disadvantage of this technique is donor site morbidity, which can result in prolonged pain along with sensory and gait disturbances.[3,4]

While calvarial bone possesses dense cortical bone and can be harvested with specialized scrapers to obtain cancellous graft, its use involves considerations such as risk of dural exposure.[5,6] The primary goal of maxillofacial reconstruction remains the reconstitution of both form and function. Microvascular tissue transfer evolved to

address the need for the restoration of composite defects following resection for malignancy. While this technique has greatly improved reconstruction of complex craniofacial defects, its application in pure bony mandibular reconstruction is limited. Isolated mandibular defects resulting from trauma, tumor surgery, infection, or other causes can significantly impact functions such as mastication, swallowing, and speech. These defects, if left untreated or inadequately treated, may lead to cosmetic concerns, functional restrictions, and social issues, ultimately reducing the patient's quality of life.[7,8]

The use of iliac crest bone grafts remains a cornerstone in maxillofacial reconstruction, providing a reliable source of autologous bone for defect restoration. Despite its widespread application, there is a need to evaluate the evolution of research trends, key contributors, institutional impact, and emerging advancements in this field. While numerous clinical studies have focused on surgical techniques and outcomes, a comprehensive bibliometric analysis has been lacking. This study aims to delve deep into publication trends, keyword evolution, and global research collaborations, ultimately guiding future research directions.

2. Methods

Data Collection and Search Strategy

Information for this bibliometric study was gathered using the Web of Science electronic database (Clarivate Analytics, Philadelphia, PA, USA) in February 2025. Web of Science is an international scientific citation index with access to a broad range of scholarly literature. For this study, literature on iliac crest graft use in oral and maxillofacial reconstruction from January 1, 1990, to December 31, 2024, was considered. To ensure a comprehensive and reproducible search, the following search string was used in the Web of Science "Topic" field (TS):

(TS=("iliac crest" OR "iliac bone" OR "hip graft" OR "hip bone graft") AND TS=("maxillofacial reconstruction" OR "mandibular reconstruction" OR "oral reconstruction" OR "jaw reconstruction" OR "dental implant"))

The search was limited to articles and review articles published between January 1, 1990, and December 31, 2024. The literature search was conducted in Web of Science Core Collection Citation Indexes, including Science Citation Index Expanded (SCI-Expanded), and Social Sciences Citation Index (SSCI). Book chapters, conference proceedings, editorials, retracted publications, and letters were excluded from the analysis during the data extraction phase to ensure the dataset consisted primarily of original and review articles. Web of Science citation information for the resulting dataset was downloaded and archived as full records and cited references in tab-delimited file format. Downloaded data included core bibliometric measures such as publication by institution, publication by country, publication by funding agency, and publication by author. The measures were analyzed to determine trends in research, top contributors, and global trends in the field of research into iliac crest grafts for oral and maxillofacial reconstruction.

Data Analysis

The extracted citation data were imported into VOSviewer (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands) for network analysis. The term maps generated for software analysis were created using the following settings: "create a map based on bibliographic data," "read data from bibliographic database files," "type of analysis: Co-occurrence," "unit of analysis: all keywords," and "counting method: full counting". To improve accuracy and consistency, a thesaurus file was created to merge synonymous terms, correct spelling variations, and exclude general terms that may not be relevant to the analysis. Additionally, synonyms related to iliac crest graft procedures -such as "iliac crest graft" and "hip bone graft"- were merged to ensure the software recognized them as the same term. This process allowed VOSviewer to analyze keywords found in titles and abstracts of publications and establish relationships based on their co-occurrence.

The collected data were analyzed using bibliometrix package in R (R Foundation for Statistical Computing, Vienna, Austria) programming language using R Studio (RStudio, Inc., Boston, MA). Metrics such as publication counts, citation trends, co-authorship networks, and keyword co-occurrence were evaluated. VOSviewer was employed to create visual maps illustrating collaboration

networks between authors, institutions, and countries along with keyword co-occurrences and density plots. We used R for data visualization regarding word cloud of keywords, tree map of keywords, country collaboration chord diagram and publication trends. Lastly, geographic trends in iliac crest graft research for oral and maxillofacial reconstruction were analyzed by creating country-specific publication maps using RStudio. These maps illustrated the distribution of research output across different countries from 1990 to 2024, providing insights into the global contribution to this field.

3. Results

Publication Trends

This bibliometric study examines research publications related to iliac crest graft use in oral and maxillofacial reconstruction from 1990 to 2024, using data retrieved from the Web of Science database. The dataset includes 2,512 documents published in 529 different sources. The field has experienced an annual growth rate of 2.35%, with an average document age of 13.8 years. Each document has received an average of 32.16 citations, and the dataset includes 43,901 references in total, reflecting the substantial and enduring academic interest in this field.

The composition of the literature is detailed in the publication trends. The majority of publications were research articles, accounting for 2,171 documents (86.5%), highlighting the primary focus on experimental and clinical research. Review articles comprised 7% of the dataset (177 documents), while conference proceedings papers (126 documents, 5%) suggest active participation in professional meetings. Early access articles (16 documents, 0.6%) and book chapters (22 documents, 0.9%) contribute to the body of literature in smaller proportions.

The evolution of research output has shown a steady upward trajectory. From only a handful of papers in the early 1990s, the annual publication volume grew to over 100 per year by 2009. This upward trend continued, peaking at 123 papers in 2013. The overall annual growth rate of 2.35% confirms the sustained and increasing interest in this field, likely driven by advancements in surgical techniques, biomaterials, and clinical applications.

The field is highly collaborative and globalized. The dataset comprises 3,281 Keywords Plus and 3,643 Author's Keywords, indicating a wide range of multidisciplinary research focuses. The field has been shaped by contributions from 8,768 authors, with an average of 5.03 co-authors per document. International collaboration is evident, with 13.81% of publications being co-authored across multiple countries. Figure 1 illustrates the annual publication output and cumulative citation count, visually confirming the sustained growth trend over the 34-year study period.

Most Influential Journals

The field has been shaped by contributions from several high-impact journals, as detailed in Table 1. Among them, *Plastic and Reconstructive Surgery* is the most influential, with 115 articles and 7,777 citations, demonstrating its pivotal role in disseminating research. The *Journal of Oral and Maxillofacial Surgery* follows closely as the most prolific journal, with 205 articles and 7,272 citations. Another significant contributor is *Clinical Oral Implants Research*, which has published 97 articles with 5,613 citations, emphasizing its role in implant-based reconstruction studies.

Other notable journals include the *Journal of Cranio-Maxillofacial Surgery* and the *International Journal of Oral and Maxillofacial Surgery*, which have consistently published research on bone grafting and reconstruction techniques. The high citation counts in these journals suggest they serve as primary sources for surgeons and researchers. It should be noted that Table 1 includes methodological outliers like the *Journal of the American Ceramic Society*, which have very few publications but high citation counts; their inclusion reflects the broad interdisciplinary nature of the initial search rather than their status as core contributors to the clinical field.

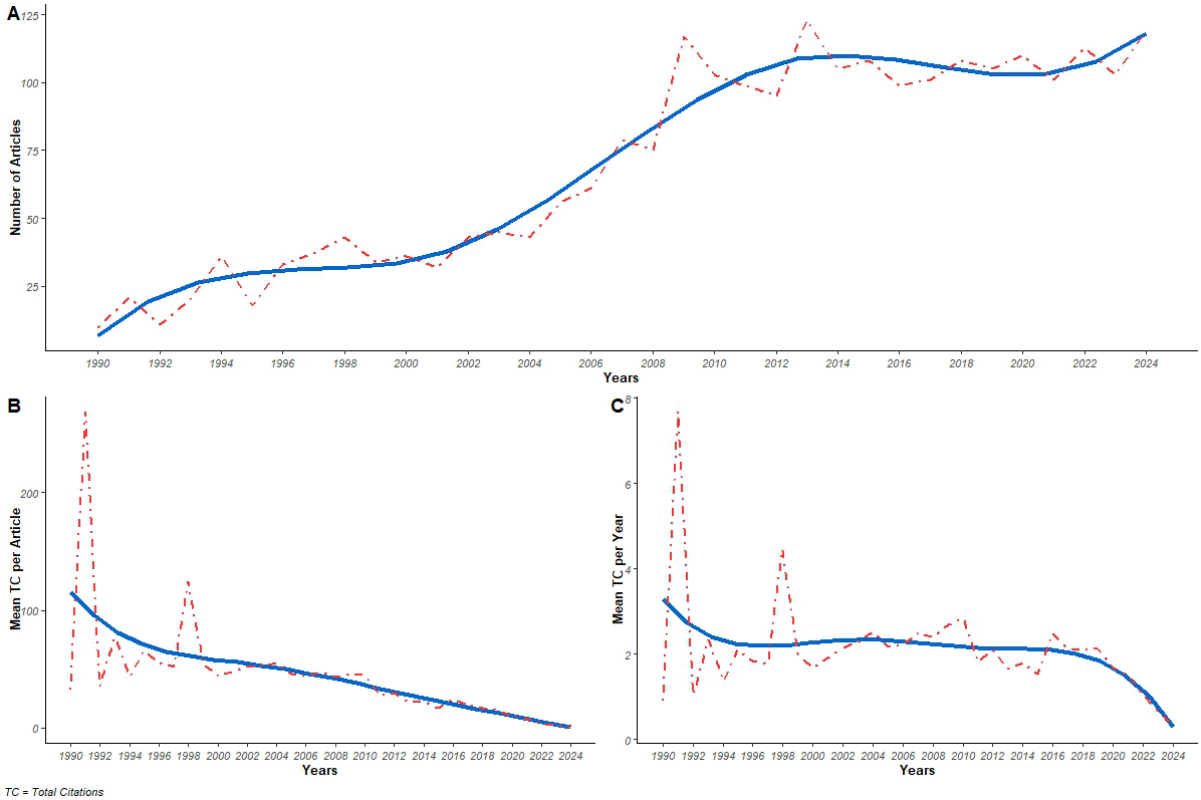

Figure 1. Annual publication trends and cumulative citations for research on iliac crest grafts in maxillofacial reconstruction (1990-2024).

Table 1. Top 20 Journals in the Field of Iliac Crest Graft and Maxillofacial Reconstruction.

#	Name	NOD	NOC	HI	GI	MI
1	*Plastic and Reconstructive Surgery*	115	7777	49	86	0.89
2	*Journal of Oral and Maxillofacial Surgery*	205	7272	50	76	1.14
3	*Journal of The American Ceramic Society*	2	6790	2	2	0.06
4	*Clinical Oral Implants Research*	97	5613	45	72	1.55
5	*Journal of Cranio-Maxillofacial Surgery*	136	4263	36	58	0.97
6	*International Journal of Oral and Maxillofacial Surgery*	135	4083	36	58	0.90
7	*International Journal of Oral & Maxillofacial Implants*	76	2781	28	51	0.97
8	*Journal of Craniofacial Surgery*	183	2427	23	39	0.74
9	*Biomaterials*	8	2224	8	8	0.25
10	*Acta Orthopaedica Scandinavica*	1	2170	1	1	0.02
11	*British Journal of Oral & Maxillofacial Surgery*	77	1884	24	40	0.62
12	*Cleft Palate-Craniofacial Journal*	52	1466	22	36	0.67
13	*Archives of Otolaryngology-Head & Neck Surgery*	10	1434	9	10	0.26
14	*Annals of Plastic Surgery*	28	1005	16	28	0.36
15	*European Journal of Oral Implantology*	8	950	8	8	0.44
16	*Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology*	28	921	16	28	0.35
17	*Clinical Implant Dentistry and Related Research*	41	905	18	29	0.86
18	*Head and Neck-Journal for The Sciences and Specialties of The Head and Neck*	27	861	16	27	0.44
19	*Angle Orthodontist*	4	730	4	4	0.13
20	*Injury-International Journal of The Care of The Injured*	4	671	4	4	0.22

NOD: number of documents; NOC: number of citations; HI: h-index; GI: g-index; MI: m-index.

Note: The presence of journals with very few publications but high citation counts (e.g., *Journal of the American Ceramic Society*, *Acta Orthopaedica Scandinavica*) are outliers likely cited for methodological innovations rather than representing core literature in the field, reflecting the interdisciplinary nature of the research.

Leading Authors and Institutions

Several authors have emerged as key contributors to the field, with their citation metrics summarized in Table 2. Urken, ML is the most influential author, with 16 published articles and 2,039 citations, reflecting his substantial contributions to reconstructive surgical techniques. Buchbinder, D and Raghoebar, GM also rank among the top researchers, with 13 and 23 publications, respectively, and significant citation counts. Their work primarily focuses on surgical advancements and patient outcomes in maxillofacial reconstruction. The collaborative networks between these and other leading authors are further visualized in the co-citation network map presented in Figure 2.

Institutional contributions are equally noteworthy, with the top performers listed in Table 5. Mount Sinai Medical Center (USA) leads the field with 14 publications and 1,750 citations. The University of California, Los Angeles (USA), and the Università di Bologna (Italy) also feature prominently, each with over 20 publications and high citation counts. European institutions, particularly those in Germany, the Netherlands, and Sweden, have also made significant research contributions, often emphasizing biomaterials and innovative reconstructive approaches. The extensive collaboration between these major research institutions is mapped in Figure 3.

Keyword Analysis and Emerging Trends

Keyword analysis provides valuable insights into thematic trends and major research areas. The top 40 keywords by frequency are listed in Table 3. The most frequently occurring term is "Iliac Crest" (413 occurrences), highlighting its dominance as the preferred donor site. Other common keywords include "Dental Implants" (399 occurrences), "Reconstruction" (386 occurrences), and "Defects" (288 occurrences), indicating a strong focus on reconstructive procedures. Notably, terms like "Morbidity" (169 occurrences) and "Complications" (104 occurrences) suggest an ongoing research interest in assessing the risks and long-term outcomes of these procedures.

Further analysis of keyword co-occurrence reveals that research is multidimensional, covering topics from bone augmentation to free-flap techniques. The main research themes and their relative frequencies are illustrated in the keyword word cloud [Figure 4] and tree map [Figure 5], which provide a visual representation of the field's focus areas.

Table 2. Top 20 authors in the field of Iliac Crest Graft and Maxillofacial Reconstruction.

#	Name	NOD	NOC	HI	GI	MI
1	*Urken, ML*	16	2039	14	16	0.40
2	*Buchbinder, D*	13	1865	12	13	0.34
3	*Raghoebar, GM*	23	1290	17	23	0.57
4	*Felice, P*	15	1233	13	15	0.62
5	*Neukam, FW*	17	992	13	17	0.41
6	*Vissink, A*	19	954	13	19	0.52
7	*Koole, R*	15	799	13	15	0.35
8	*Wolff, KD*	14	773	12	14	0.40
9	*Wiltfang, J*	20	772	12	20	0.48
10	*Heiland, M*	13	725	11	13	0.58
11	*Ten Bruggenkate, CM*	12	663	9	12	0.32
12	*Hölzle, F*	38	646	14	24	0.82
13	*Chiapasco, M*	11	616	10	11	0.37
14	*Meijer, GJ*	13	611	11	13	0.61
15	*Schmelzeisen, R*	23	579	13	23	0.36
16	*Sennerby, L*	10	502	10	10	0.36
17	*Stoelinga, PJW*	12	500	10	12	0.42
18	*Sbordone, C*	12	495	10	12	0.50
19	*Sbordone, L*	11	495	10	11	0.50
20	*Guidetti, F*	10	491	10	10	0.59

NOD: number of documents; NOC: number of citations; HI: h-index; GI: g-index; MI: m-index.

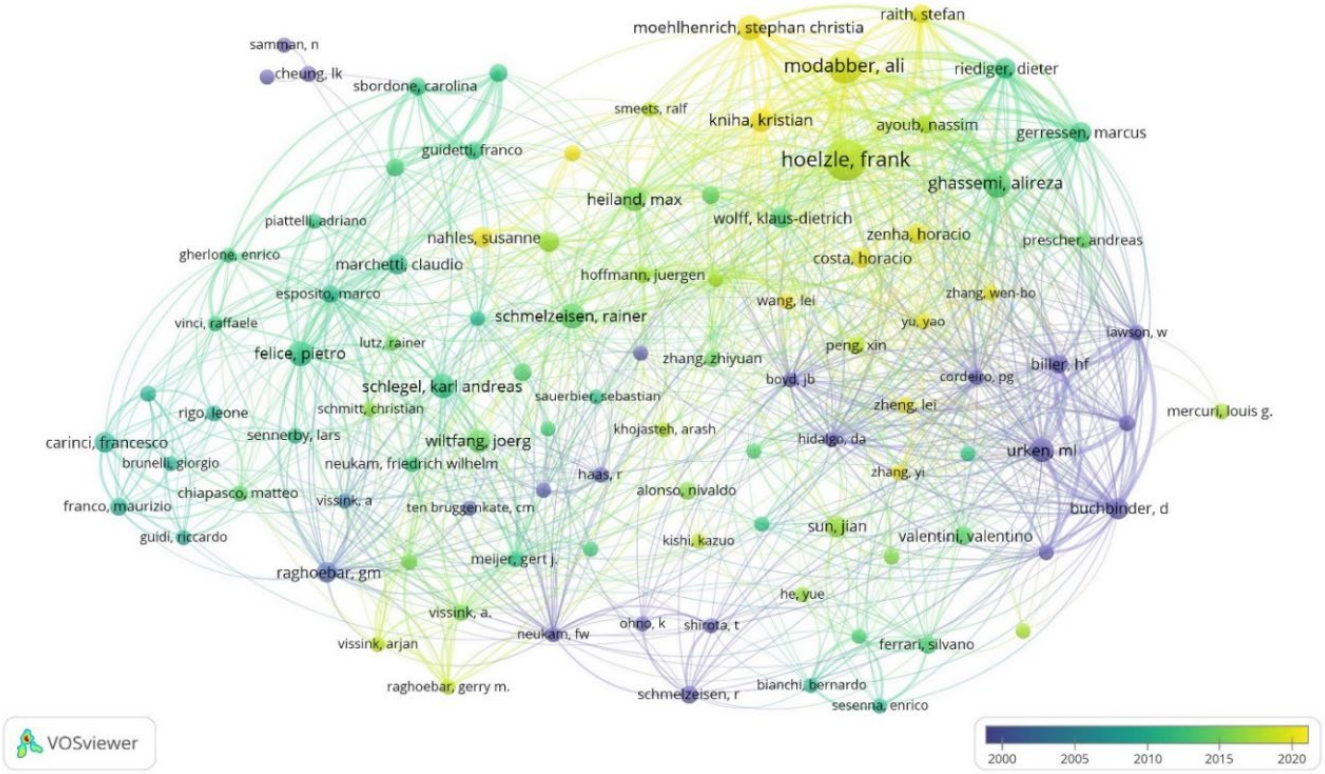

Figure 2. Network visualization of co-citation relationships among leading authors.

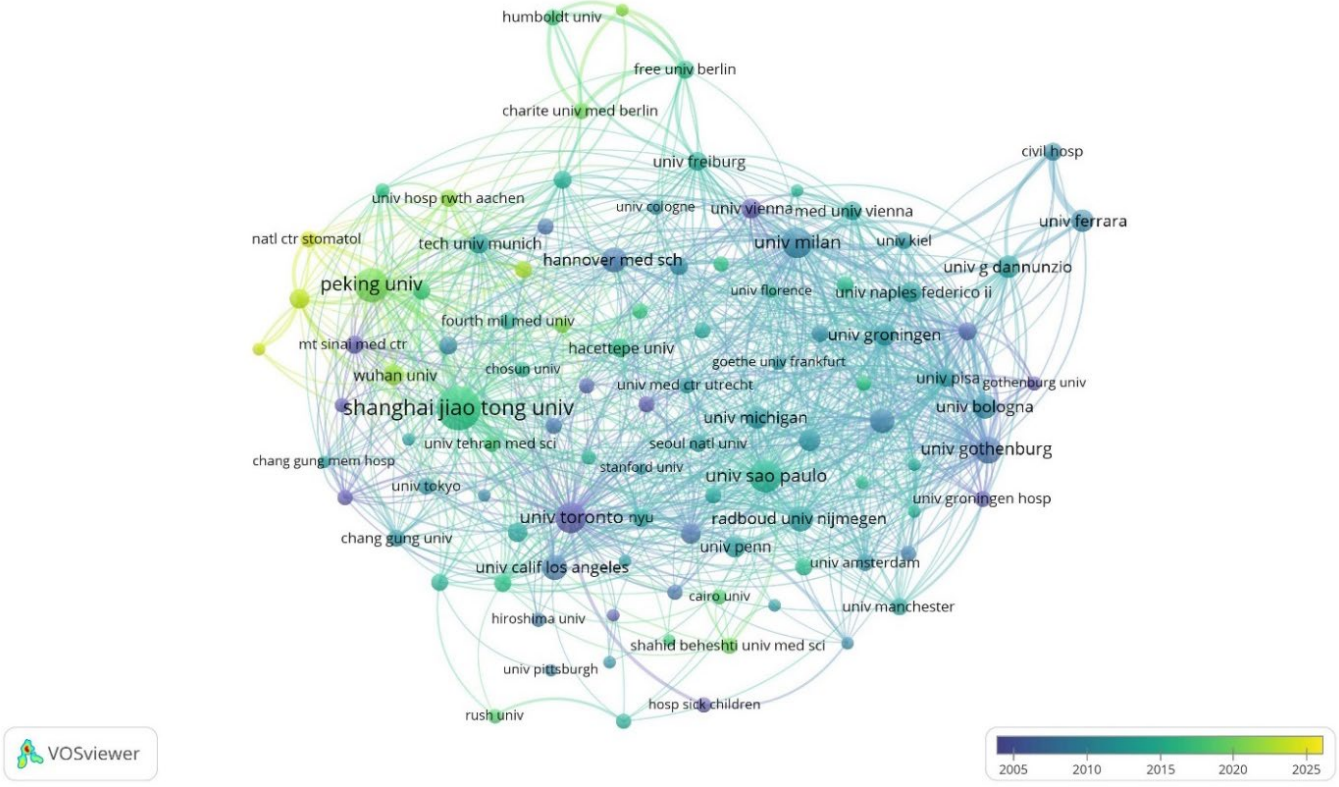

Figure 3. Collaboration network among major research institutions.

Table 3. Top 40 keywords in the field of Iliac Crest Graft and Maxillofacial Reconstruction.

#	Name	Occurrence	#	Name	Occurrence
1	*Iliac Crest*	413	*21*	*Placement*	91
2	*Dental Implants*	399	*22*	*Sinus Augmentation*	90
3	*Reconstruction*	386	*23*	*Follow-Up*	86
4	*Defects*	288	*24*	*Management*	86
5	*Graft*	273	*25*	*Maxilla*	86
6	*Mandibular Reconstruction*	182	*26*	*Regeneration*	86
7	*Augmentation*	178	*27*	*Residual Alveolar*	86
8	*Morbidity*	169	*28*	*Experience*	83
9	*Head*	168	*29*	*Neck Reconstruction*	76
10	*Surgery*	159	*30*	*Rehabilitation*	74
11	*Bone-Graft*	153	*31*	*Flap*	72
12	*Bone*	136	*32*	*Crest*	70
13	*Lip*	125	*33*	*Platelet-Rich Plasma*	68
14	*Oromandibular Reconstruction*	124	*34*	*Marrow Stromal Cells*	65
15	*Autogenous Bone*	121	*35*	*Outcomes*	65
16	*Palate*	118	*36*	*Anterior*	62
17	*Repair*	110	*37*	*Donor Site*	62
18	*Free-Flap*	108	*38*	*Immediate Reconstruction*	62
19	*Complications*	104	*39*	*Cancellous Bone*	57
20	*Endosseous Implants*	102	*40*	*Mesenchymal Stem-Cells*	54

Geographic Distribution of Research

A significant portion of research has been produced by a few key countries, as shown in Table 4. It is important to note that due to international co-authorship, the sum of publications from all countries exceeds the total document count (2,512), as multi-country publications are counted for each contributing nation.

The United States leads the field, contributing 463 publications and 19,953 citations, with a strong focus on domestic research (369 SCP) but also a meaningful proportion of international collaborations (43 MCP). Germany (330 publications, 9,358 citations) and China (241 publications, 3,547 citations) follow as the other primary contributors. European nations like Italy and the Netherlands demonstrate significant contributions, reflecting their instrumental role in developing surgical techniques and biomaterials.

Table 4. Top 20 Countries by Research Output in the Field of Iliac Crest Graft and Maxillofacial Reconstruction.

#	Country	NOD	NOC
1	USA	463	19953
2	Germany	330	9358
3	China	241	3547
4	Italy	189	5525
5	Japan	172	4182
6	the Netherlands	118	5193
7	Brazil	110	1522
8	England	97	7258
9	Canada	79	2948
10	Turkey	77	1063
11	Austria	76	2190
12	France	71	1951
13	South Korea	70	980
14	Sweden	68	5042
15	Spain	48	1035
16	Switzerland	42	1683
17	Australia	36	1238
18	Taiwan	32	1177
19	Israel	26	816
20	Greece	17	718

NOD: number of documents; NOC: number of citations.

The Chord Diagram [Figure 6] powerfully illustrates these international research collaborations, showing strong partnerships among the USA, Germany, China, Italy, and Japan. The growing number of internationally co-authored papers indicates a clear trend toward

globalized research efforts. This global network is further contextualized by the three-field plot [Figure 7], which visualizes the relationships between countries, frequently used keywords, and core journals, highlighting the interconnectedness of the global research landscape in this field. Finally, Figure 8 displays the most frequently cited sources within the dataset, underscoring the foundational literature that has shaped the field's development.

Table 5. Top 20 Institutions in the Field of Iliac Crest Graft and Maxillofacial Reconstruction.

Institution	COI	NOD	NOC
Mount Sinai Medical Center	USA	14	1750
University of California, Los Angeles	USA	23	1678
Università di Bologna	Italy	22	1442
University of Gothenburg	Sweden	27	1313
Harvard University	USA	16	1217
University of Milan	Italy	32	1129
University of Erlangen-Nuremberg	Germany	22	1088
Shanghai Jiao Tong University	China	60	1045
Louisiana State University	USA	11	1016
University Medical Center Groningen	the Netherlands	11	1002
Hannover Medical School	Germany	24	966
University of Manchester	UK	12	912
University of Groningen	the Netherlands	20	876
Umea Universitet	Sweden	14	792
University of Bern	Switzerland	13	786
University of Pennsylvania	USA	18	751
University of Naples Federico II	Italy	17	740
University Medical Center Hamburg-Eppendorf	Germany	14	718
University of Maryland	USA	13	694
Technical University of Munich	Germany	16	669

NOD: number of documents; NOC: number of citations; COI: country of institute.

Figure 4. Word cloud of frequently occurring keywords, with size proportional to occurrence frequency.

Figure 5. Tree map visualization of keyword distribution and relative frequency.

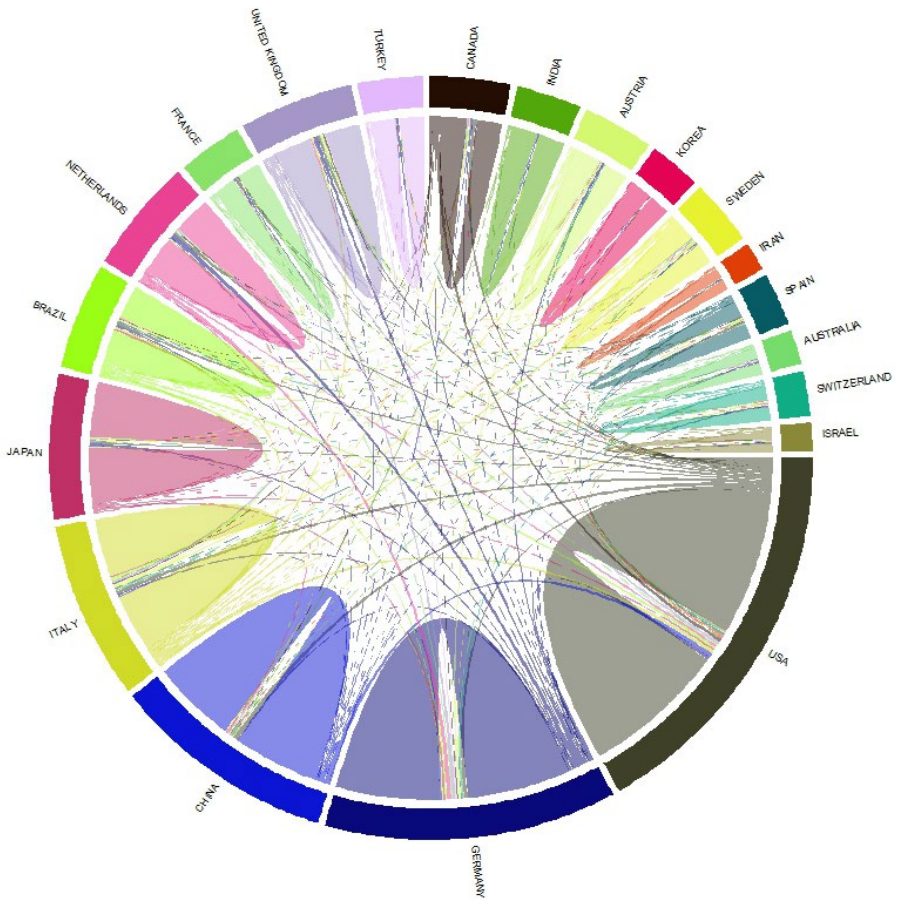

Figure 6. Chord diagram illustrating international collaboration patterns between countries.

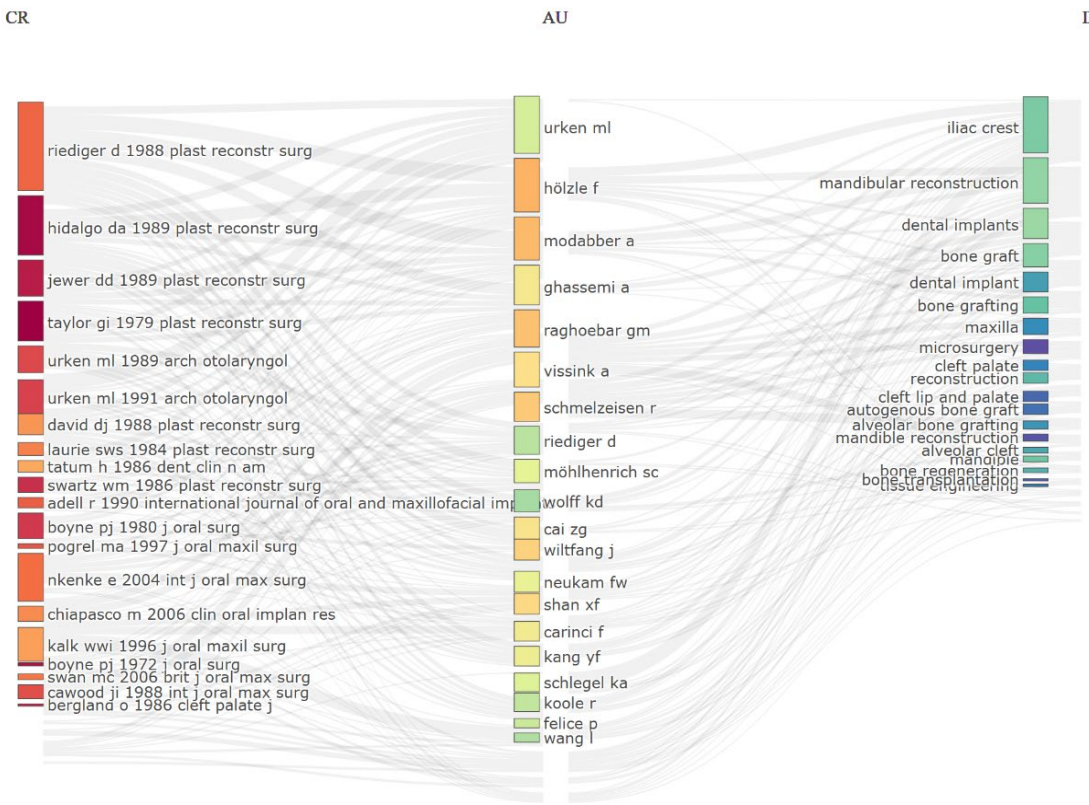

Figure 7. Three-field plot showing relationships between countries, keywords, and journals.

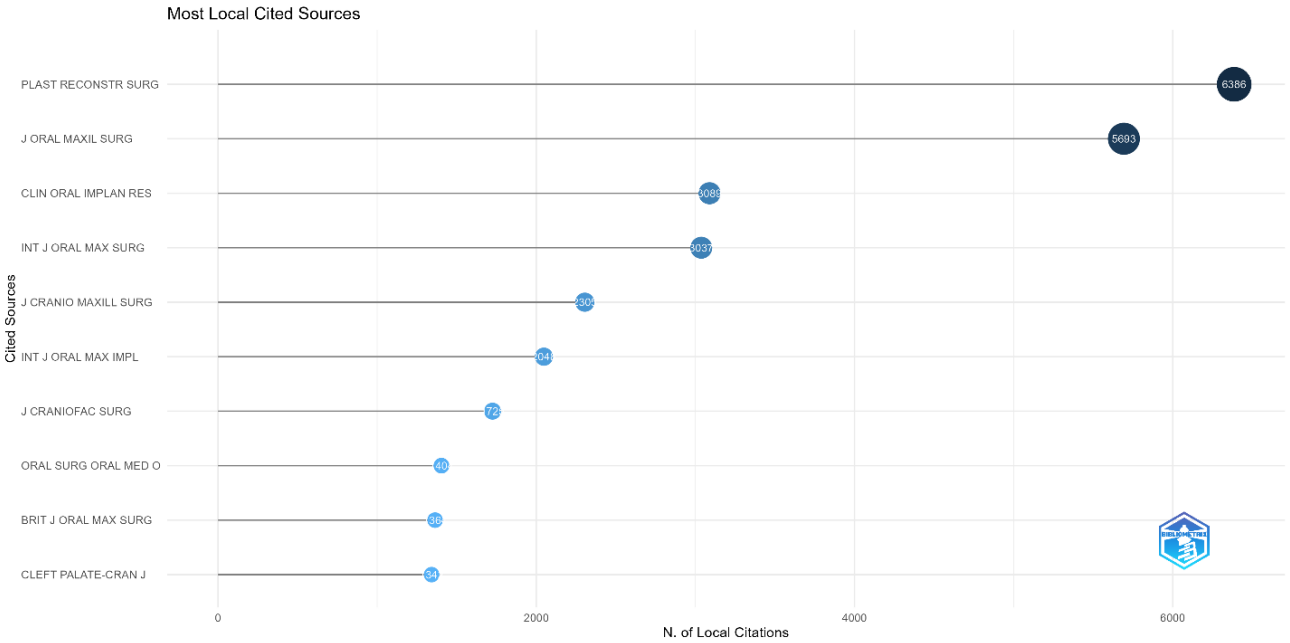

Figure 8. Most frequently cited sources within the dataset.

4. Discussion

This bibliometric analysis provides a comprehensive overview of global research trends in the use of iliac crest bone grafts for maxillofacial reconstruction over the past three decades. The findings reveal a steady annual growth rate of 2.35% in publications, underscoring sustained and growing academic and clinical interest in this field.[1,2] The *Journal of Oral and Maxillofacial Surgery* and *Plastic and Reconstructive Surgery* emerged as the most influential journals, serving as primary platforms for disseminating

advancements in surgical techniques, outcomes research, and biomaterial applications. Leading authors such as Urken ML, Raghoebar GM, and Neukam FW were identified as key contributors, whose work has significantly shaped contemporary practices in microvascular reconstruction and grafting methodologies. Institutionally, Mount Sinai Medical Center and the University of California, Los Angeles, stood out as central research hubs, reflecting their pivotal roles in both clinical innovation and scholarly output. Geographically, the United States, Germany, and China dominated research production, with robust international collaborations evident across Europe and Asia. Keyword analysis highlighted persistent core themes such as "iliac crest," "dental implants," "mandibular reconstruction," and "bone graft," while also revealing emerging trends in tissue engineering, regenerative medicine, and minimally invasive techniques. These findings collectively affirm the importance of iliac crest grafting in maxillofacial surgery and signal a shifting paradigm toward biologically enhanced, patient-specific approaches aimed at improving functional and aesthetic outcomes while reducing donor site morbidity.[3,4]

The leadership of the USA, Germany, and China in research output is likely attributable to several factors, including substantial investment in healthcare research, advanced medical infrastructure, and a high volume of complex maxillofacial cases requiring reconstruction.[7,8] The United States has long been a pioneer in craniofacial surgery and reconstructive innovation, supported by well-funded academic medical centers and a strong culture of interdisciplinary collaboration. Germany's contributions are rooted in its rigorous academic tradition and expertise in biomaterial science and surgical engineering, while China's rapidly growing publication count reflects its expanding healthcare capabilities and increasing focus on complex surgical care. The strong transatlantic collaboration between North American and European institutions, particularly between the USA and Germany, suggests a shared commitment to advancing surgical techniques, improving patient outcomes, and standardizing postoperative care protocols. Moreover, the notable rise of China as a major contributor indicates a shifting global research landscape, with Asia emerging as a significant player in maxillofacial reconstruction research, potentially driven by growing investments in medical education, surgical training, and healthcare infrastructure.

The interdisciplinary nature of iliac crest grafting is reflected in the dominance of journals such as the *Journal of Oral and Maxillofacial Surgery* and *Plastic and Reconstructive Surgery*. These journals bridge specialized oral and maxillofacial surgery with broader reconstructive disciplines, including plastic surgery, otolaryngology, and biomedical engineering. Their high impact factors and citation rates confirm their role as essential resources for surgeons and researchers seeking the latest advancements in grafting materials, surgical procedures, and long-term outcome studies. The identification of authors such as Urken, Raghoebar, and Neukam as field leaders is consistent with their renowned contributions to microvascular reconstruction, graft integration, and patient-specific treatment planning. Their work has not only advanced surgical techniques but also helped establish evidence-based guidelines for donor site selection, graft handling, and postoperative management.

Keyword analysis offers valuable insights into the evolution of research focus within the field. While traditional terms such as "iliac crest," "dental implants," and "mandibular reconstruction" remain central, the emergence of terms like "tissue engineering," "platelet-rich plasma," "marrow stromal cells," and "mesenchymal stem cells" signals a paradigm shift toward biologically enhanced reconstruction strategies.[5,6] This trend aligns with broader movements in regenerative medicine and suggests that future research will increasingly integrate biological adjuvants with conventional grafting techniques to improve osteogenesis, accelerate healing, and reduce complication rates. The persistent focus on terms such as "complications" and "morbidity" reflects ongoing concerns regarding donor site outcomes, including pain, sensory disturbance, gait alteration, and aesthetic defects.[3,4] These concerns have driven research into less invasive harvesting techniques, improved perioperative management, and the development of alternative bone sources and bone substitute materials.

Maxillofacial reconstruction presents unique challenges

due to the complex three-dimensional anatomy of the facial skeleton and its critical roles in mastication, speech, swallowing, and facial expression.[9,10] The primary goals of reconstruction include re-establishing bony continuity, restoring functional occlusion, and achieving satisfactory aesthetic outcomes.[11] Defects in this region are generally classified as marginal or segmental. Marginal defects involve the alveolar process without compromising skeletal continuity, whereas segmental defects result in discontinuity of the jawbone. Reconstruction of marginal defects typically focuses on alveolar ridge augmentation to support dental implants or prosthetic rehabilitation. In contrast, segmental defects require the restoration of structural integrity and often involve more extensive grafting procedures. Small lateral segmental defects (less than 5 cm) in non-irradiated patients can often be managed with non-vascularized bone grafts.[12] However, larger defects or those in irradiated fields usually necessitate vascularized free tissue transfer to ensure adequate blood supply and promote healing.[13] Anterior defects are particularly challenging due to their aesthetic and functional significance, as well as the risk of loss of tongue support and potential airway compromise if not properly reconstructed.[12,13]

The iliac crest remains the donor site of choice for non-vascularized bone grafts due to its abundant supply of corticocancellous bone, ease of access, and compatibility with maxillofacial reconstruction requirements.[1,2] Both the anterior and posterior iliac crest offer substantial volumes of bone, with the anterior site providing up to 50 cc of uncompressed cancellous bone and the posterior site yielding up to 100 cc. The anterior iliac crest is particularly favored for defects up to 5 cm in length, while the posterior site is reserved for larger reconstructions. A detailed understanding of regional anatomy is essential for safe and effective graft harvest.[14,15] The anterior iliac crest is located between the anterior superior iliac spine (ASIS) and the tubercle of the ilium, approximately 6 cm posterior to the ASIS. This region contains the highest concentration of cancellous bone and is associated with several key muscular attachments, including the external abdominal oblique medially and the tensor fascia lata laterally. To minimize postoperative gait disturbances and pain, surgical dissection is generally limited to the medial aspect of the crest, avoiding excessive lateral dissection that could disrupt the tensor fascia lata and gluteal muscles.[14,15]

Sensory nerves in the region, including the lateral femoral cutaneous nerve, iliohypogastric nerve, and subcostal nerve, are at risk during anterior iliac crest harvest. The lateral femoral cutaneous nerve, in particular, courses near the ASIS in approximately 2.5% of the population, and injury can result in meralgia paresthetica-a condition characterized by persistent numbness, tingling, or burning pain in the lateral thigh.[14,15] Vascular supply to the area is derived primarily from the deep circumflex iliac artery and vein, with the gluteal artery representing a significant source of potential bleeding during surgery. These anatomical considerations underscore the importance of meticulous surgical technique to avoid neurovascular injury and reduce donor site morbidity.[14,15]

The surgical approach to the anterior iliac crest involves a carefully placed incision 1-2 cm posterior to the tubercle of the ilium and 1 cm inferior to the ASIS. This placement helps avoid injury to sensory nerves and ensures that the scar lies lateral to the crest, reducing irritation from clothing.[16,17] Dissection proceeds through a relatively avascular plane between the tensor fascia lata laterally and the abdominal muscles medially. After periosteal incision, the iliacus muscle is reflected medially to protect intra-abdominal structures. Bone may be harvested as cancellous chips via a "clamshell" technique or as a corticocancellous block graft. It is crucial to preserve at least 1-2 cm of bone posterior to the ASIS to avoid fracture, and the depth of harvest should not exceed 5 cm, where the anterior and posterior cortical plates converge.[18,19]

Complications associated with anterior iliac crest harvest include infection, hematoma, seroma, gait disturbance, fracture, chronic pain, and abdominal herniation.[20,21] Gait disturbances are often related to excessive lateral dissection and detachment of the gluteal muscles, while fractures may result from overharvesting or weakening of the ASIS. Most gait issues resolve with physical therapy, and fractures are typically managed conservatively with restricted weight-bearing.[20,21]

The posterior iliac crest provides the largest volume of

cancellous bone and is ideal for reconstructing defects up to 10 cm in length.[22] The bone is concentrated beneath the gluteus maximus insertion near the sacroiliac joint. Sensory nerves at risk include the superior and middle cluneal nerves, which supply the medial buttock. The sciatic nerve lies 6-8 cm inferior to the crest and is generally not encountered during routine dissection.[22,23] The patient is positioned prone, often with hip flexion to improve access. A curvilinear incision is made centered over the gluteus maximus insertion, avoiding the cluneal nerves. Dissection involves transecting the lumbodorsal fascia and reflecting the gluteus maximus and medius muscles to expose the crest. A cortical window osteotomy allows access to the cancellous bone, which is then harvested with curettes. Hemostasis is achieved with bone wax or hemostatic agents, and closure includes reapproximation of the fascia and often placement of a drain to prevent fluid accumulation.[9,17,24,25]

The bibliometric data also highlight an increasing focus on strategies to reduce donor site morbidity and improve graft integration. These include the use of minimally invasive harvesting techniques, advanced hemostatic methods, and the application of growth factors and stem cells to enhance bone healing. The emergence of keywords related to "3D printing," "computer-assisted surgery," and "patient-specific implants" points toward a future in which reconstruction is increasingly personalized and precision-based. Digital planning and custom-made guides and implants allow for more accurate graft shaping and placement, reducing operative time and improving functional and aesthetic outcomes.

Furthermore, the integration of tissue engineering approaches -such as mesenchymal stem cells, platelet-rich plasma, and bioactive scaffolds- holds promise for reducing the need for autogenous bone harvest or supplementing smaller grafts to achieve adequate reconstruction.[5,6] These biologically augmented approaches may eventually lead to protocols that minimize donor site morbidity while maintaining high success rates in graft integration and long-term stability.

Several limitations of this study should be acknowledged. First, the analysis was restricted to the Web of Science database, which may exclude relevant publications indexed in other databases such as Scopus, PubMed, or Embase. Second, despite the use of a comprehensive search strategy, some relevant articles may have been missed due to variations in terminology or indexing. Third, bibliometric analysis quantifies research productivity and impact but does not assess the clinical quality or methodological rigor of individual studies. Fourth, the counting method for international collaborations -where multi-country publications are counted for each contributing nation- results in a sum of publications that exceeds the total document count, which may complicate the interpretation of geographic distributions. Finally, this analysis captures trends up to 2024, and rapidly evolving areas such as robotic surgery, advanced biomaterials, and gene-activated scaffolds may not be fully represented in the current dataset.

Despite these limitations, this bibliometric study offers valuable insights into the intellectual structure and evolving trends in iliac crest graft research. The consistent growth in publications, the robust network of international collaboration, and the clear shift toward biologically enhanced and digitally guided techniques all indicate a dynamic and forward-moving field. Future research directions will likely focus on the integration of 3D-printed scaffolds, stem cell technologies, and bioactive molecules to develop personalized grafting solutions that optimize outcomes while minimizing patient morbidity. By mapping the historical development and current state of the field, this analysis provides a foundation for clinicians and researchers to identify gaps, opportunities, and collaborative partnerships that will drive the next generation of innovations in maxillofacial reconstruction.

5. Conclusions

This bibliometric study provides a comprehensive analysis of research trends in iliac crest grafting for maxillofacial reconstruction, highlighting key contributors, influential institutions, and emerging scientific themes. The steady growth in publications and citations underscores the continuing importance of iliac crest bone grafting in reconstructive surgery. Findings indicate that the USA, Germany, and China lead in research output, with strong international collaborations

fostering advancements in surgical techniques and biomaterials. The *Journal of Oral and Maxillofacial Surgery* and *Plastic and Reconstructive Surgery* were identified as the most impactful publication sources, while keyword analysis revealed a shift towards tissue engineering, regenerative medicine, and minimally invasive techniques. As surgical innovations continue to evolve, future research is expected to focus on patient-specific grafting solutions, 3D printing technologies, and stem cell applications, further improving clinical outcomes and reducing donor site morbidity. By recognizing historical advancements and identifying emerging trends, this study provides valuable insights for researchers and clinicians seeking to enhance maxillofacial reconstruction techniques using iliac crest bone grafts.

Acknowledgment

None.

Competing interests

The authors declare that they have no competing interests.

Abbreviations

Social Sciences Citation Index: SSCI;

Anterior Superior Iliac Spine: ASIS.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

Funding

None.

Role of the funding source

None.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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Cite this article as:
Akhavan-Sigari R. Global Research Trends in Iliac Crest Grafts for Maxillofacial Reconstruction: A Comprehensive Bibliometric Analysis. J Cancer Res Pharmacol. 2025;1(1):12-26. doi: 10.22034/jcrph.2025.229250