

Global Mapping Analysis of Maxillofacial Trauma Literature From 1980-2022

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ABSTRACT

Objective: The study is aimed to make a comprehensive bibliometric analysis of the literature in the field of maxillofacial trauma (MFT), to determine the focal points and to present the results in a simplified manner by using various mapping methods. In addition, it is aimed to determine the important articles that constitute the main backbone of the MFT literature with objective methods and to provide a source for education and new studies in this field.**Methods:** The publications related to maxillofacial traumas between 1980-2022 using the search terms “injury, trauma, fracture, facial, mandible, mandibular, nasal, midface, orbit, ocular, maxilla, maxillary” were obtained from the Web of Science Core Collection database. Nodes and connections were created using CiteSpace software to create the maps used in the visualization. Cooperation between countries, distribution of topics, co-citation, co-citation clustering analysis were applied.**Results:** There were 8850 publications and 78216 references. The MFT literature was divided into a total of 16 clusters. The most published topic was about mandible fractures. While there was a very strong correlation between the country’s gross national product and the number of publications ($R=0.886$), there was a moderate correlation between the country’s population and the number of publications ($R=0.403$).**Conclusion:** In the presented study, the forty-years history of the MFT literature was evaluated with bibliometric analysis methods; the most influential publications, the topics in which the literature is divided and hot spots were determined.**Keywords:** Maxillofacial trauma; Mapping analysis; Bibliometric analysis

INTRODUCTION

The face, which is the most important structure of individuals’ social identities, is a structure consisting of many units responsible for various vital functions. The brain, eyes, nose and jaws are the most important units of this structure [1]. Maxillofacial trauma (MFT) includes any external injury to the hard and soft tissues of the head and face region. Traumas to these areas include abrasion, laceration, contusion, hematoma, rupture, burn, bone fractures, etc. may form [2]. The complexity of the structures found in this region complicates the management of MFTs and concerns professionals from a variety of specialties.

Science, by its nature, is constantly growing. The number of academic publications in the field of MFT has increased, as in many other fields, due to many reasons such as the ease of communication and transportation between countries, the increase in the number of academic journals and the ease of access to these journals. However, determining the impact of a scientific paper can be difficult [3]. Bibliometric analysis is a method of measuring the effectiveness and trends of a discipline by using features such as the number of articles and publications in databases, the number of citations, and the year

of publication. This method helps to assess the popularity of a discipline and the impact of publications in related fields [4, 5]. There were previous bibliometric analysis studies on MFT [6–8]. However, these studies did not have a comprehensive reference and mapping analysis to assess the extent to which the publications contributed to the literature. Science mapping and visualization helps to discover scientific knowledge [3, 4]. In particular, document co-citation analysis enables identification of relevant literature and academic communities as well as societal impacts that may be overlooked in standard approaches to literature review [3, 4, 9].

In this study, it is aimed to make a comprehensive bibliometric analysis of the literature in the field of MFT, to determine the focal points and to present the results in a simplified manner by using various mapping methods. In addition, it is aimed to determine the important articles that constitute the main backbone of the MFT literature with objective methods and to provide a source for education and new studies in this field.

MATERIALS AND METHODS

This study, which is a bibliometric global mapping analysis study, is exempt from ethics committee approval [10]. The search was performed on the Web of Science Core Collection database on 27.12.2022 to avoid bias due to daily database updates. Search settings ([injury] OR [trauma] OR [fracture]) AND ([facial] OR [mandible] OR [mandibular] OR [nasal] OR [midface] OR [orbit] OR [ocular] OR [maxilla] OR [maxillary]) was applied to include search terms and all document types, with a time range of 1980-2022.

CiteSpace software was utilized to generate visual maps depicting nodes and connections. These maps were instrumental in analyzing various elements such as cited countries, journals, and authors. Each node on the map represented an item of

analysis, with its size corresponding to the frequency of citation. Nodes were color-coded to denote different years, while the connecting lines between nodes represented co-occurrence or co-citation relationships. The thickness of the lines indicated the strength of the relationship. Co-citation analysis was employed to identify common focal points and hot research topics. Additionally, statistical methods were applied to compare demographic characteristics of countries and the outcomes derived from data analysis. The relationship between the two quantitative data was evaluated with the Pearson Correlation test. Calculated correlation (r) between two variables: a value of r less than 0.20 and values close to zero indicates a very weak relationship; a value between 0.20 and 0.39 suggests a weak relationship; a value between 0.40 and 0.59 indicates a moderate relationship; a value between 0.60 and 0.79 signifies a high level of correlation; if the value is between 0.80 and 1.0, it is interpreted as a very high correlation.

RESULTS

General Outputs

There were 8850 publications and 78216 references. Although there were some fluctuations during the study period, the annual logistic growth rate of the number of publications was 4.05%.

Cross-Country Cooperation

There were 122 nodes and 482 connections in the cooperation network between countries (Figure 1). The size of the circles represents the number of co-citations, while the red circles inside the circles represent the citation bursts. The United States was the country with the most publications with 4863 publications, followed by India (629), England (562), China (426) and Germany (354).

The relationship between the number of publications and the country's population and the country's gross national product (GDP) was evaluated with the Pearson Correlation test. While there was a moderate correlation ($R=0.403$) between the number of publications and the population, there was a very strong correlation ($R=0.886$) between GDP.

Subject Distribution

Mandible fractures (37.36%) were the most common topic. This was followed by Orbital (25.77%), Facial (25%), Cranial (10.46%), Maxillary (6.07%), Mandibular Condyle (3.26%) and Cervical Spinal (0.35%) traumas. The subject distribution of the

Main Points;

- The United States was the leading country with the highest number of publications and citations.
- The most published topic was about mandible fractures.
- The maxillofacial trauma literature was divided into a total of 16 clusters.
- While there was a moderate correlation between the number of publications and the population, there was a very strong correlation between gross national product.

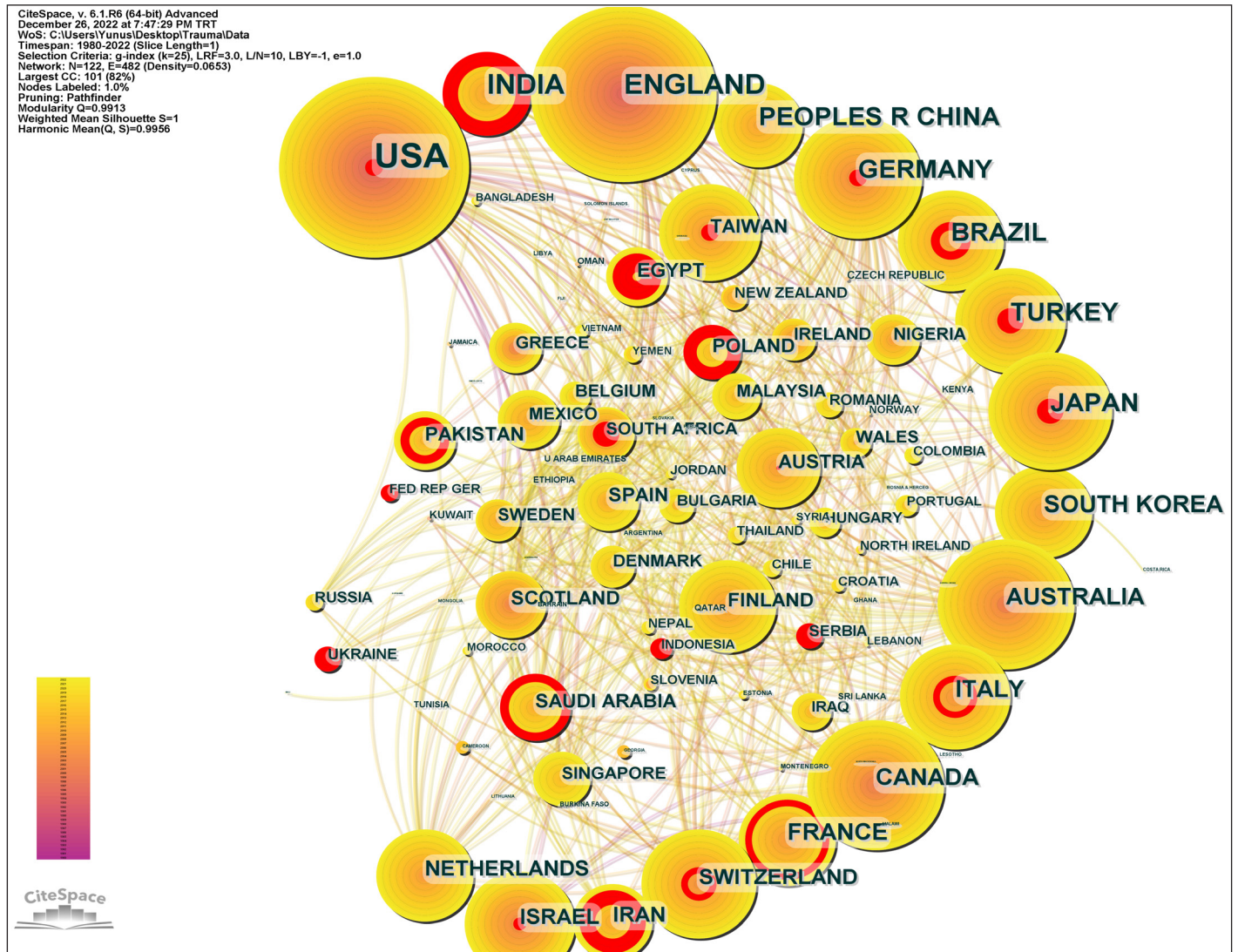


Figure 1. Cross-country cooperation map.

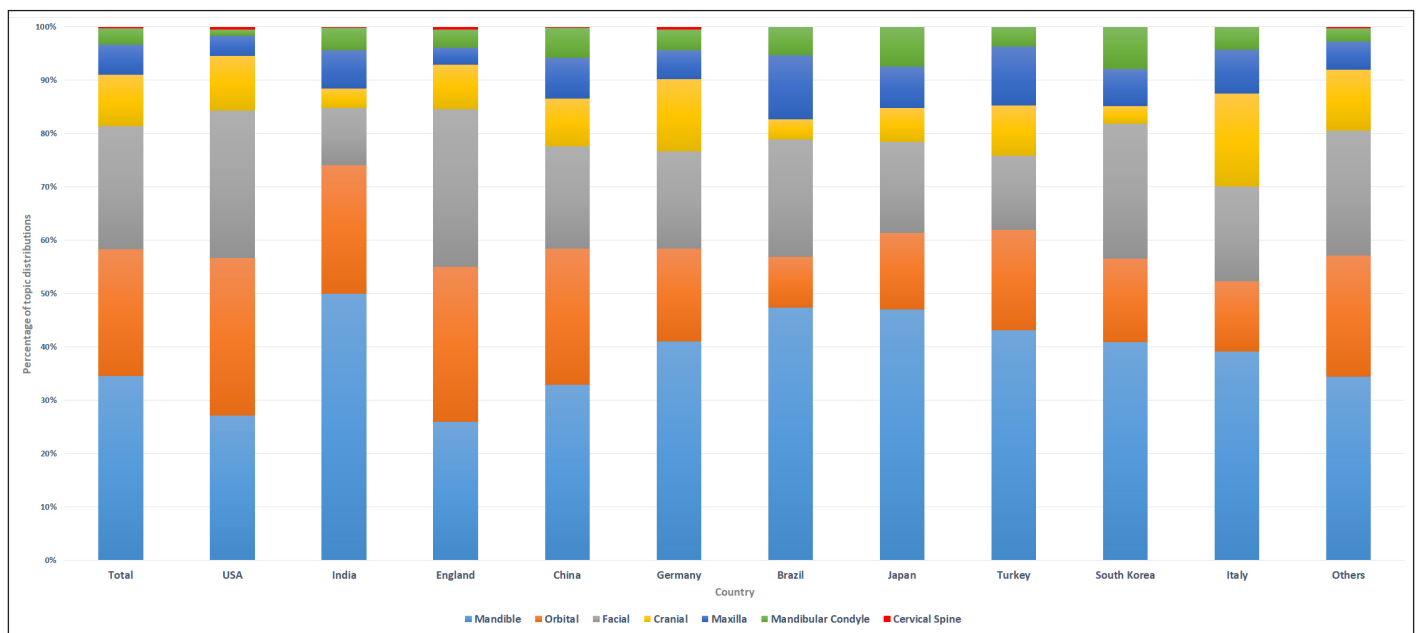


Figure 2. Subject distributions according to fracture localization.

publications of the top 10 countries with the highest number of publications is shown in Figure 2.

Co-citation Analysis

Figure 3 illustrate the co-citation network pertaining to MFT publications. In this visual representation, the nodes correspond to the cited references, while the links between the nodes indicate shared citation relationships. Following the completion of co-citation analysis, a total of 1590 nodes and 5272 connections were identified (Figure 3).

The most cited publication was Mansour-Robaey et al.[11], with 670 citations. The largest radius reference (most co-cited publication) in the network was that of Champy et al [12], with 312 co-citations. The highest citation burst was for Rowe's publication[13] and had a duration of 11 years. The top 10 articles that are most cited, most co-cited, and that have the strongest citation burst are summarized in Table 1.

Co-citation Cluster Analysis

Cluster analysis is mapped in Figure 4. The timeline format

of the cluster analysis is shown in Figure 5. As a result of this analysis, it was seen that the MFT literature was formed under 16 main cluster headings. Clusters from largest to smallest are labeled from 0 to 17. The largest cluster was related to mandibular angle fracture, followed by mandibular condylar fracture, pediatric facial fracture and ocular trauma. Cluster labels were determined according to Log-likelihood ratio (LLR), Latent Semantic Indexing (LSI) and Mutual information (MI), and the characteristics of the clusters are summarized in Table 2.

DISCUSSION

Although scientific articles are in the past tense from the time they were published, citations to these articles form the basis for future new publications. They also serve as a source for new articles, training and treatments in the field. By making a detailed analysis of the scientific literature in a particular field, the progress of that subject over time can be followed and the future path of the literature can be predicted [3, 4]. In this study, a bibliometric analysis of the MFT literature was made and it was aimed to make the analysis results simple and easy to understand with the maps created.

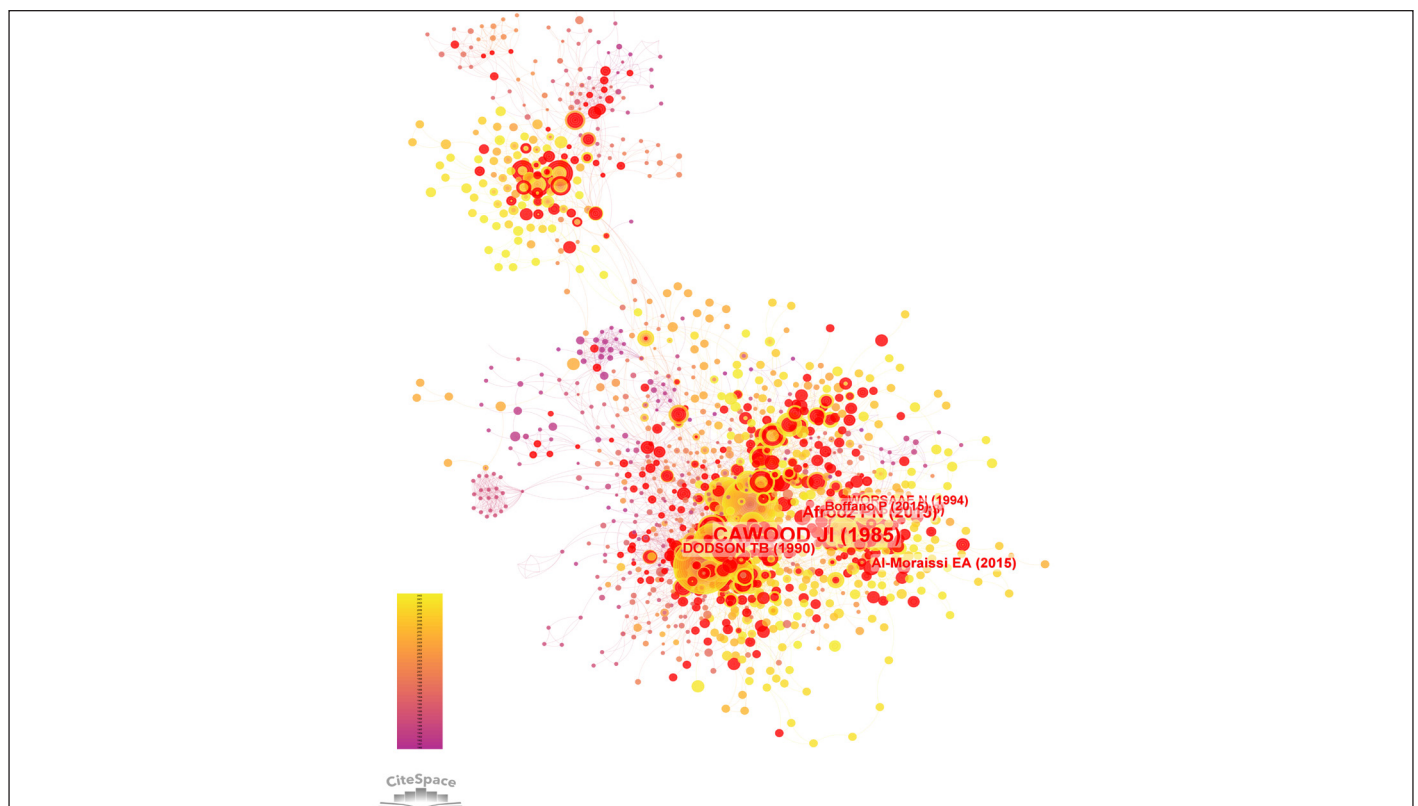


Figure 3. Co-citation analysis map. Each node represents references. Node size is directly proportional to the amount of co-citation. The greater the relationship between the two nodes, the thicker the connecting line. The red circles around the nodes represent the citation explosion.

Table 1. Top 10 articles with the highest metric values

Top 10 Most Cited Articles		Top 10 Co-cited Articles		Top 10 Articles with the Strongest Citation Bursts		
Count	References	Count	References	Year Range	Strength	References
670	Effects of ocular injury and administration of brain-derived neurotrophic factor on survival and regrowth of axotomized retinal ganglion cells (8)	312	Mandibular osteosynthesis by miniature screwed plates via a buccal approach (9)	1988-1999	24.56	Small plate osteosynthesis of mandibular fractures (20)
385	Ten years of mandibular fractures: an analysis of 2137 cases (21)	257	Ten years of mandibular fractures: An analysis of 2137 cases (21)	2018-2022	20.28	The Epidemiology of Mandibular Fractures in the United States, Part 1: A Review of 13,142 Cases from the US National Trauma Data Bank (22)
292	A standardized classification of ocular trauma (23)	146	Cranio-maxillofacial trauma: a 10 year review of 9,543 cases with 21,067 injuries (24)injury surveillance and research data describe the whole spectrum of injuries. The goal of this study was to assess the effect of the five main causes of accidents resulting in facial injury on the severity of cranio-maxillofacial trauma. PATIENTS AND METHODS: During a period of 10 years (1991-2000	1991-1999	17.19	Fixation of mandibular fractures: A comparative analysis of rigid internal fixation and standard fixation techniques (25)
258	An epidemiologic survey of facial fractures and concomitant injuries (1) age and sex of the patients, cause of injury, and associated systems injuries are presented. The majority of facial fractures were found in males; the most prevalent age range was 16 to 30 years. Mandible fractures outranked zygomatic and maxillary fractures (6:2:1	139	The global impact of eye injuries (26) the available information on eye injuries from an epidemiological and public health perspective has been extensively reviewed. This collection of data has allowed an analysis of risk factors, incidence, prevalence, and impact of eye injuries in terms of visual outcome. However, most of the estimates are based on information from More Developed Countries (MDCs	2017-2022	16.64	Surgical Treatment of Adult Mandibular Condylar Fractures Provides Better Outcomes Than Closed Treatment: A Systematic Review and Meta-Analysis (17)
258	Indications for open reduction of mandibular condyle fractures (27)	137	Osteosynthesis with miniaturized screwed plates in maxillo-facial surgery (28)	1998-2008	16.08	Rigid fixation of mandibular condyle fractures (29)

220	Penetrating ocular injuries. Types of injuries and visual results (30)	130	An epidemiologic survey of facial fractures and concomitant injuries (1)age and sex of the patients, cause of injury, and associated systems injuries are presented. The majority of facial fractures were found in males; the most prevalent age range was 16 to 30 years. Mandible fractures outranked zygomatic and maxillary fractures (6:2:1	2016-2022	15.56	European Maxillofacial Trauma (EURMAT) project: A multicentre and prospective study (31)causes and characteristics of maxillofacial fractures managed at several European departments of oral and maxillofacial surgery over one year. The following data were recorded: gender, age, aetiology, site of facial fractures, facial injury severity score, timing of intervention, length of hospital stay. Data for a total of 3396 patients (2655 males and 741 females
210	Fractures of the mandibular condyle: a review of 466 cases. Literature review, reflections on treatment and proposals (32)	129	Treatment methods for fractures of the mandibular angle (33)	1997-2010	15.26	Surgical versus nonsurgical treatment of unilateral dislocated low subcondylar fractures: A clinical study of 52 cases (34)
201	Open versus closed treatment of fractures of the mandibular condylar process - a prospective randomized multi-centre study (35)	124	Fractures of the mandibular condyle: a review of 466 cases. Literature review, reflections on treatment and proposals (32)	1980-1991	14.99	Fractures of the facial skeleton in children (10)
199	Cortical innervation of the facial nucleus in the non-human primate - A new interpretation of the effects of stroke and related subtotal brain trauma on the muscles of facial expression (36)	122	The Ocular Trauma Score (OTS) (37)	2008-2015	14.85	Pediatric facial fractures: Evolving patterns of treatment (38)
190	Pediatric facial fractures: evolving patterns of treatment (39)location and pattern of facial fractures, pattern of facial injury, soft tissue injuries, and any associated injuries to other organ systems were recorded, and fracture management and perioperative complications reviewed. The study population consisted of 137 patients who sustained 318 facial fractures. Eighty-one patients (171 fractures	119	Open versus closed treatment of fractures of the mandibular condylar process—a prospective randomized multi-centre study (35)	2016-2022	14.54	What Method for Management of Unilateral Mandibular Angle Fractures Has the Lowest Rate of Postoperative Complications? A Systematic Review and Meta-Analysis (15)

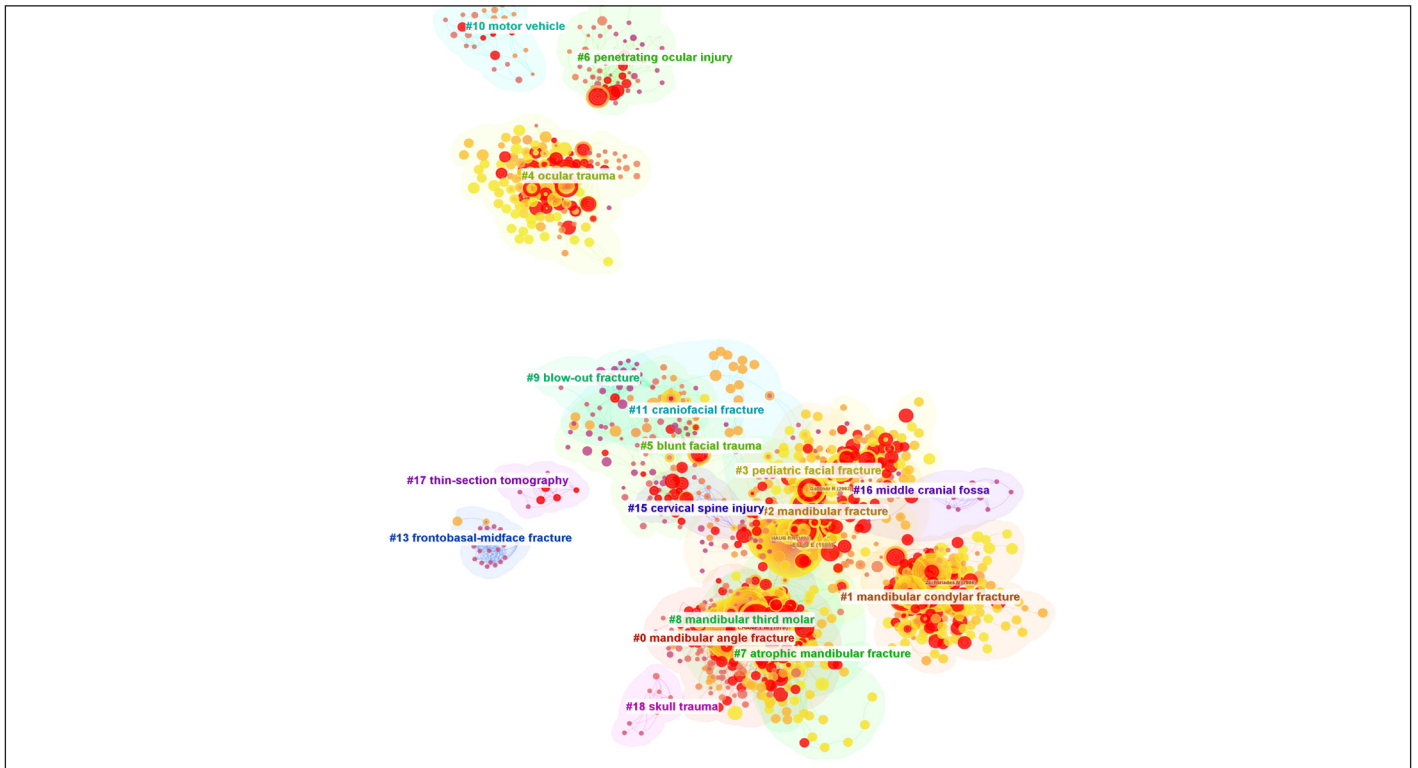


Figure 4. Co-citation cluster analysis map

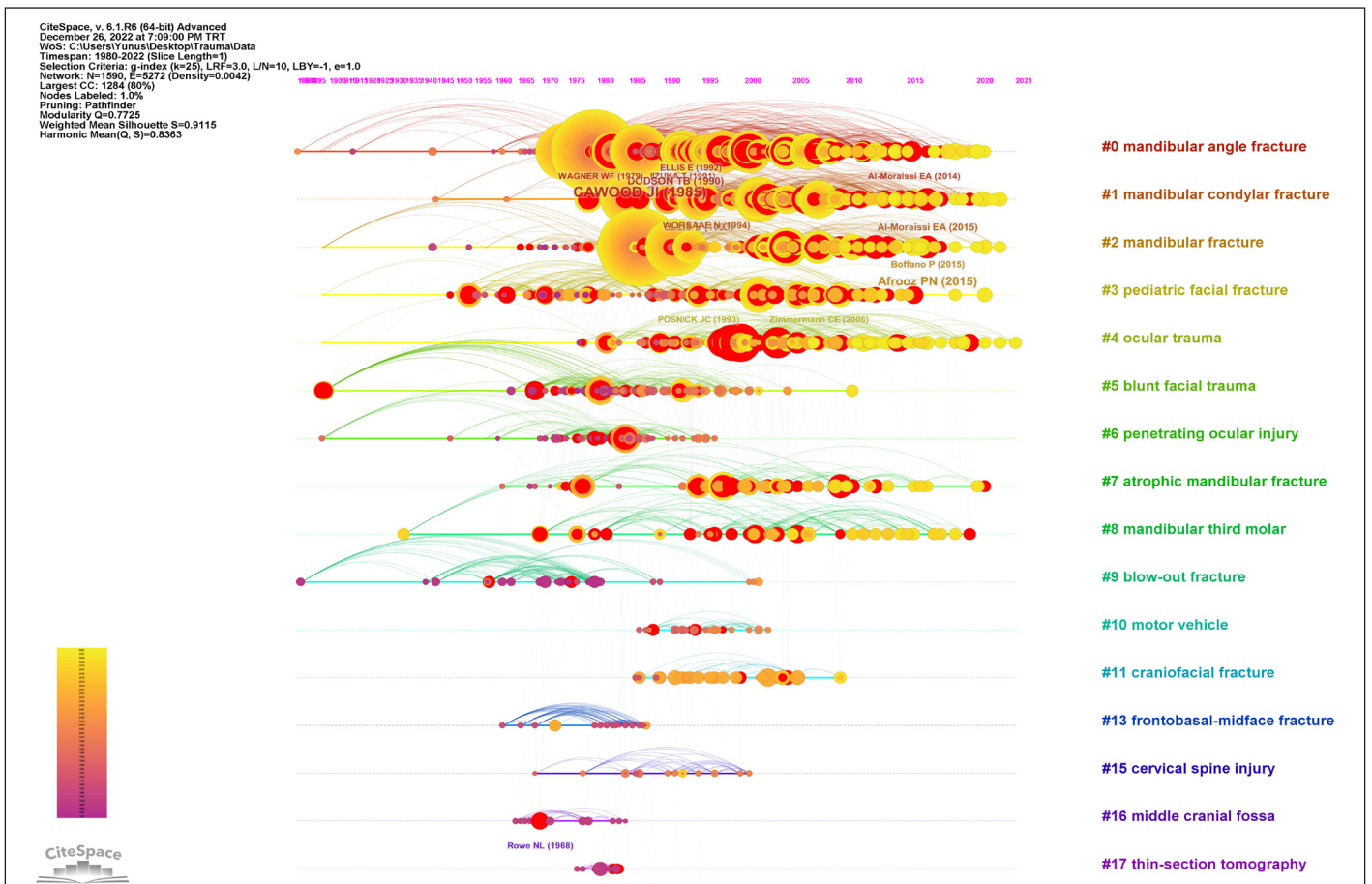


Figure 5. Co-citation cluster analysis timeline map

Table 2. Clusters into which the craniomaxillofacial trauma literature is divided, silhouette values of clusters, size of clusters, labels of clusters (according to LSI, LLR, and MI), and main articles of clusters

Cluster ID	LLR	LSI	MI	Size	Silhouette	The major citing article of the cluster
#0	mandibular angle fracture	mandibular angle fracture	facial plastic-surgery (3.43)	264	0.851	Fixation of mandibular angle fractures: clinical studies (40)
#1	mandibular condylar fracture	mandibular condyle fracture	facial plastic-surgery (1.76)	174	0.954	Does the surgical approach for treating mandibular condylar fractures affect the rate of seventh cranial nerve injuries? a systematic review and meta-analysis based on a new classification for surgical approaches (41)
#2	mandibular fracture	mandibular fracture	facial plastic-surgery (3.14)	160	0.872	Facial fractures in children and adolescents: a retrospective study of 3 years in a hospital in belo horizonte, brazil (16)
#3	pediatric facial fracture	pediatric facial fracture	paediatric mandibular condylar fracture (0.49)	140	0.874	Pediatric facial fractures: recent advances in prevention, diagnosis and management (42)
#4	ocular trauma	ocular trauma	multi-center cross-sectional study (0.91)	128	0.963	Epidemiology of severe ocular trauma following the implementation of alcohol restrictions in far north Queensland (43)
#5	blunt facial trauma	facial fracture	mini-fragment bone plate (0.1)	103	0.844	High-resolution ct analysis of facial struts in trauma .2. osseous and soft-tissue complications (44)
#6	penetrating ocular injury	penetrating ocular injury	mandibular fracture (0.08)	58	0.989	Vitrectomy in severe ocular trauma (19)
#7	atrophic mandibular fracture	mandibular fracture	fractured atrophic edentulous mandible (0.14)	51	0.935	Complications of locking and non-locking plate systems in mandibular fractures (45)
#8	mandibular third molar	mandibular angle	mandibular fracture (0.06)	40	0.955	Do mandibular third molars play a role in fractures of the mandibular angle and condyle? (46)
#9	blow-out fracture	blow-out fracture	mandibular fracture (0.09)	30	0.984	Another look at blow-out fractures of the orbit (47)
#10	motor vehicle	motor vehicle	mandibular fracture (0.09)	27	0.99	Do motor vehicle airbags increase risk of ocular injuries in adults? (48)
#11	craniofacial fracture	craniofacial fracture	mandibular fracture (0.09)	27	0.987	Surgical strategy for complex craniofacial fractures (2)
#13	frontobasal-midface fracture	subcranial management	mandibular fracture (0.09)	23	0.997	The surgical one-stage management of combined cranio-maxillo-facial and frontobasal fractures - advantages of the subcranial approach in 374 cases (49)
#15	cervical spine injury	subcranial management	mandibular fracture (0.09)	14	0.969	Prevalence of cervical spine injuries in patients with facial trauma (50)
#16	middle cranial fossa	middle cranial fossa	mandibular fracture (0.09)	12	0.996	Mandibular condyle fracture and dislocation into the middle cranial fossa (51)
#17	thin-section tomography	facial trauma	mandibular fracture (0.09)	11	0.999	Computed-tomography and thin-section tomography in facial trauma (52)

There is no direct relationship between GNP and facial trauma, but depending on a country's economic situation and access to health services, access to facial trauma treatment and the quality of treatment may vary. For example, in countries with low GNP access to healthcare may be limited and thus facial trauma treatment may also be affected. Likewise, countries with high GNP may have better access to health care and better treatment opportunities. Therefore, there may be an indirect relationship between GNP and facial trauma. As a result of our analysis, there was a very strong correlation ($R=0.886$) between GNP and the number of MFT publications in countries. This does not necessarily lead to the conclusion that countries with high GNP have a large number of MFTs, but it does indicate that these countries allocate higher treatment and research budgets for the treatment of MFTs.

It is difficult to say that there is a direct relationship between the rate of facial trauma and the population of the country. The facial trauma rate is calculated based on the percentage of the country's population of the number of facial traumas that occur in a country. This rate may differ between countries and may be affected by various factors [14]. The reason for the moderate correlation ($R=0.403$) between the number of MFT publications and the country population in this study may be that the incidence of facial trauma is affected by the country population in two ways. For example, a high rate of facial trauma in a country may be caused by reasons such as high traffic density, high speed limits, and lack of road safety in the country. At the same time, the low rate of facial trauma may be due to the effectiveness of road safety improvement efforts in the country.

Tahim et al. [6] published a bibliometric analysis of the 100 most cited articles on facial trauma in 2016. The distribution of facial trauma subjects reported by Tahim et al.[6] was similar to that in our presented study, with mandible and orbital fractures being the most common subjects. Our study, which is presented differently from this study, includes co-citation analysis, cluster analysis, citation burst analysis, cross-country collaboration analysis and mapping of these analyzes.

Co-citation refers to the frequency with which two documents are jointly cited by other documents [4]. When two documents are cited together in at least one other document, they are considered to have a shared citation. Typically, commonly cited publications tend to cluster around specific topics [3, 15]. Co-citation cluster analysis plays a crucial role in identifying concentrated areas of

research within a discipline and determining influential studies. Moreover, this method enables the examination of the evolution of research within a discipline and aids in predicting its future direction. It encompasses various aspects such as co-citation cluster analysis, research methods, data collection, and analysis. By investigating the relationships and mutual influence among research studies in a discipline, this method sheds light on the factors shaping scientific development [3, 4]. Using Citespace, an automatic clustering of co-cited publications was conducted, revealing that the MFT literature was categorized into 16 main topics. The silhouette metric is employed to assess the uncertainty associated with determining the nature of a cluster. Ranging from -1 to 1, the silhouette value [15] represents the level of uncertainty that must be considered when interpreting the nature of a cluster. A value of 1 indicates perfect separation from other clusters [16]. In this study, the overall silhouette value was 0.9115, indicating excellent separation within the MFT literature. The modularity Q score was higher than 0.5 (0.7725), suggesting that the network was reasonably divided into loosely coupled clusters (Fig. 3.b-c). Among these clusters, Cluster #5 (LLR: blunt facial trauma LSI: facial fracture) exhibited the lowest silhouette value. The co-citation frequency for nasal, malar, and facial soft tissue traumas within this cluster was insufficient to warrant a separate topic.

When a fracture occurs in the mandible, which is one of the structures most affected by facial trauma, the treatment of this condition may vary according to the nature and severity of the fracture site, and surgical or non-surgical methods are generally used. The number and localization of mini-plates is an important question for the surgeon if open reduction is to be performed to correct the fracture [12, 17, 18]. However, when the citation bursts of the articles are examined, it is seen that the 2014[17] and 2015[19] publications of Al-Moraissi and Ellis, which is a more recent article than the article by Champy et al., are more effective today. When the power of the citation bursts is examined, we predict that these two publications by Al-Moraissi and Ellis will increase their importance in the coming years and will be a reference source for new studies on mandible fractures.

Ocular traumas have an important place among facial traumas because the eyes are an important sensory organ for humans and serious consequences such as vision loss can occur as a result of eye injuries [20, 21]. When the trauma localizations constituting the MFT literature were examined, 25.77% were related to ocular traumas when analyzed according to the cluster analysis

of co-citations. These articles were mainly concerned with the etiology, classification and treatment of ocular traumas.

The selected keywords did not include any related to cervical spinal traumas, but 0.35% of the publications were related to spinal traumas. The cervical spinal traumas identified in our analysis were only those that occurred together with MFTs. This demonstrates the severity of MFTs and the areas it affects. However, a gap in the literature is the lack of research on subjects such as brain traumas that may occur after MFTs. This situation could be due to two reasons. The first possible reason is that brain traumas in MFTs have been studied so little that they do not form a distinct cluster. The second possible reason is that brain traumas are reported as completely independent publications from MFTs.

Limitations

This study had several limitations. Only the Web of Science database was used as the database, so not all of the MFT literature from the years mentioned was analysed. However, there were enough articles about MFT in the Web of Science, which has a large database and includes academic journals of certain quality that are constantly updated.

CONCLUSION

In the presented study, the forty-years history of the MFT literature was evaluated with bibliometric analysis methods; the most influential publications, the topics in which the literature is divided and hot spots were determined. The most influential country in this area was the United States. Among MFTs, mandibular fractures were the most studied by the authors, followed by orbital traumas/injuries. MFTs can lead to vital consequences up to spinal traumas, but brain traumas associated with MFTs have not been adequately studied in the literature. It is important to focus on this issue in future studies.

Conflict of interest

The author has no conflicts of interest to disclose.

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None

Ethical Statement

This study, which is a bibliometric analysis study, is exempt from ethics committee approval.

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