

# Global research patterns and advances in comb burn treatment: a comprehensive bibliometric analysis

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## ABSTRACT

**Aims:** This study conducts a bibliometric analysis of literature on stasis zones and comb burns, essential for understanding and treating burn injuries. The comb burn model, introduced by Regas and Ehrlich,<sup>1</sup> has facilitated animal studies on burn pathophysiology. The Jackson burn model categorizes burns into three zones: coagulation, stasis, and hyperemia, with the stasis zone posing significant treatment challenges. Utilizing animal models, especially rats, is common in burn research.

**Methods:** The comb burn model uses a heated brass comb to study the stasis zone effectively. A PubMed search identified 68 relevant articles, analyzed using Biblioshiny within R Studio.

**Results:** Results indicated that “Burns: Journal of the International Society for Burn Injuries” and “Journal of Burn Care & Research” are key journals. The United States, China, and Turkiye are leading countries in this research area. The study emphasizes the need for standardized methodologies and improved animal models.

**Conclusion:** The analysis highlights the necessity for ongoing research and international collaboration to advance comb burn understanding and treatment.

**Keywords:** Comb burns, bibliometrics, research trends, academic analysis, burn injuries

## INTRODUCTION

The comb burn model, introduced by Regas and Ehrlich,<sup>1</sup> paved the way for various animal studies to explore the pathophysiology and treatment of the stasis zone in burns.<sup>1</sup> The objective of this study is to conduct a bibliometric analysis of the existing literature on stasis zones and comb burns.

Burn injuries are generally classified by depth, but the Jackson burn model categorizes them into three zones regardless of depth: coagulation, stasis, and hyperemia.<sup>2</sup> Early research showed that these zones evolve over time, with the stasis zone either progressing to necrosis or healing and becoming part of the hyperemia zone. The coagulation zone remains constant, while the stasis zone can either deteriorate or recover, affecting treatment outcomes (Figure 1).

Jackson's studies used compression with blood pressure cuff to observe these zones: necrosis was evident in the coagulation zone, while the stasis zone had preserved circulation but no metabolic activity, and the hyperemia zone retained both circulation and metabolism.<sup>2</sup>

The stasis zone presents significant treatment challenges as it can lead to necrosis, complicating healing and increasing complications. Addressing this zone is crucial for improving burn treatment outcomes.

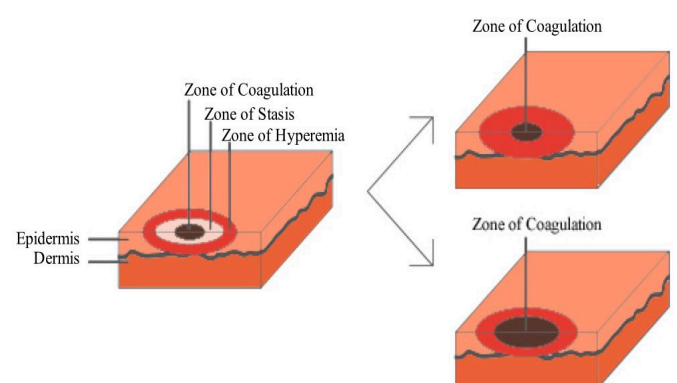


Figure 1. Stasis zone either heals or progresses to coagulation zone (Illustrated by the author)

Burn research involves complex local and systemic effects, making animal models essential for understanding these injuries and testing treatments. In vitro studies alone are inadequate due to their limitations. Rats are commonly used for burn research due to their skin's similarity to humans, though their rapid healing and high contracture rates pose challenges.<sup>3</sup> Different animal species are chosen based on the research focus, with sheep, rabbits, rats, and pigs used for various types of burn studies.

One common burn model involves scalding, where animals are exposed to hot water or metal plates. The comb burn model, which involves a heated brass comb applied to the skin, allows for studying the stasis zone more effectively. A 55x19 mm brass comb heated to 70°C creates distinct burn areas, enabling precise monitoring and measurement.<sup>1</sup>

However, this model primarily assesses superficial stasis zones, neglecting deeper layers where stasis progression is more significant. Studies have shown that applying the heated comb for 30 seconds at 100°C provides a consistent full-thickness burn, highlighting the need for standardized application times in research.<sup>4</sup>

The comb burn model has evolved to address gaps in stasis zone research, but variability in methodology exists. Standardizing application times and recognizing the limitations of the model will improve consistency and accuracy in future studies.<sup>5</sup>

The objective of this study is to conduct a comprehensive bibliometric analysis of research on the comb burn model and its application to understanding burn injury zones, with a particular focus on the stasis zone. By identifying publication trends, key contributors, and influential research networks, this analysis aims to map the global research landscape in this field. By highlighting trends, gaps, and methodological challenges, the study seeks to inform future research directions and promote standardization in the use of the comb burn model. This will ultimately support advances in burn treatment and improve outcomes for patients with burn injuries.

## METHODS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. There are no conflicts of interest to declare, and no ethical approval was required for this bibliometric analysis. All procedures were carried out in accordance with the ethical rules and the principles.

To analyze the research landscape on comb burns, a comprehensive search was conducted using the term “comb burn” in PubMed (June 2024). The study included only articles written in English, resulting in a total of 77 articles. To ensure the rigor of the analysis, irrelevant articles were excluded, leaving a total of 68 articles for further examination. The retrieved publications were exported and analyzed using the Biblioshiny program within R Studio. Biblioshiny is a web-based application designed for bibliometric analysis, offering tools for visualizing and interpreting academic literature data. Bibliometric analysis was performed to identify key trends and patterns in the comb burn research. This included visualizing publication trends over time, author contributions, journal impact, and citation patterns. The analysis also focused on mapping research networks and collaborations to highlight influential studies and researchers in the field.

## RESULTS

### Journals and Trends

As illustrated in Figure 2, the annual scientific output on comb burn research exhibits a fluctuating trend from 1992 to 2024. In the initial period between 1992 and 2006, research

activity was intermittent, with a relatively low number of publications, typically ranging from zero to two articles per year. It is noteworthy that there were several years in which no publications were produced. A gradual increase in the number of publications began around 2007, reaching a peak in 2013 with eight articles. Subsequently, the number of publications exhibited fluctuations, demonstrating intermittent increases in research activity. Another noteworthy surge occurred around 2014 and 2018, indicating a resurgence of interest or advancements in the field during these periods. Despite some variability, there has been a general upward trend in publications over the past two decades, reflecting a growing interest and research effort in comb burn studies. The slight decline in recent years suggests the necessity for sustained research focus to maintain and build upon previous advancements.

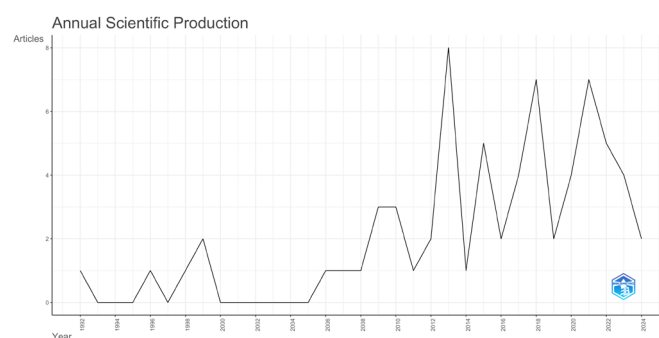


Figure 2. Number of studies published by year. It is worthy of note that the number of articles published on an annual basis has increased markedly in recent years

Figure 3 illustrates the distribution of core sources for comb burn research according to Bradford’s Law. The analysis identifies “Burns: Journal of the International Society for Burn Injuries” and the “Journal of Burn Care & Research” as the primary core sources, each contributing a significant number of articles. The steep decline in the number of articles beyond these core journals highlights their pivotal role in the field, with other sources contributing fewer publications. This distribution underscores the importance of these core journals in disseminating key research findings on comb burns.

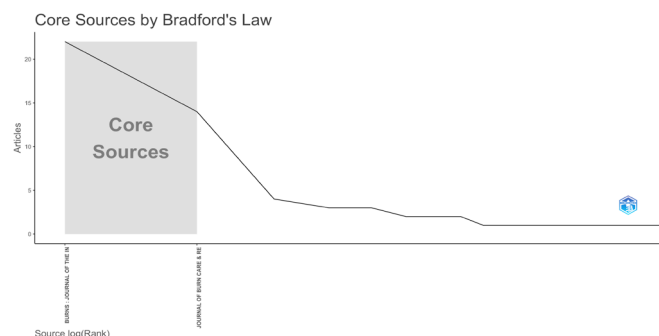


Figure 3. Core sources by Bradford’s Law shows the most efficacious journals

Figure 4 displays the most relevant sources for comb burn research, highlighting the journals with the highest number of published documents. “Burns: Journal of the International Society for Burn Injuries” leads with 22 articles, followed by the “Journal of Burn Care & Research” with 14 articles. Other notable sources include “Academic Emergency Medicine” with 4 articles, “Annals of Plastic Surgery” with 3, and

“Wound Repair and Regeneration” with 3. This distribution underscores the prominence of specialized burn and emergency medicine journals in disseminating significant research findings in the field of comb burn studies.

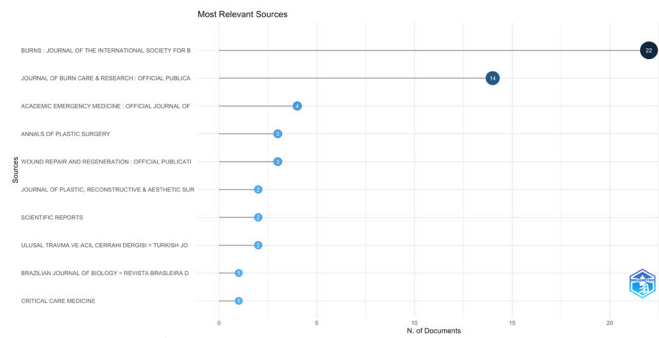


Figure 4. Most relevant sources

### Authors and Affiliations

Figure 5 illustrates the publication activity of leading authors in comb burn research over time. The chart shows consistent contributions from authors such as Singer et al.<sup>7</sup> indicating their long-term involvement and impact in the field. The size of the dots represents the number of articles published, with larger dots indicating higher productivity. Authors like Singer et al.<sup>7</sup> are notable for their sustained high output. This visualization highlights the significant and ongoing contributions of key researchers, demonstrating their pivotal roles in advancing comb burn research.

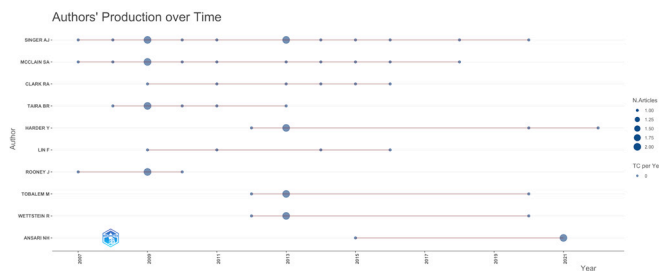


Figure 5. Authors production over time

Figure 6 highlights the most prolific authors in the field of comb burn research. Singer et al.<sup>7</sup> tops the list with 13 published documents, followed closely by McClain with 11 documents. Other notable contributors include Clark RA and Taira BR, each with 6 publications, and Harder Y with 5. Additional contributors such as Tobalem et al.<sup>5</sup> have also made significant contributions with multiple publications. This visualization underscores the key researchers who have substantially advanced the field through their extensive work on comb burn studies.

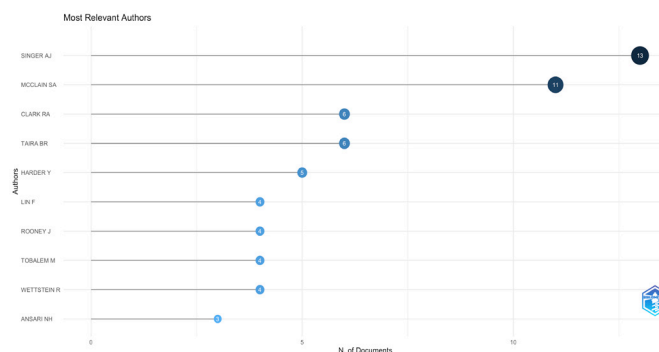


Figure 6. Most relevant authors

Figure 7 illustrates the global research networks and collaborations in comb burn studies. It reveals significant clusters of activity, highlighting key institutions and researchers as central nodes within these networks. It demonstrates that American centers have a considerable number of articles, whereas Turkiye, despite ranking highly in the country ranking, lower in affiliations and authors. The considerable quantity of Turkish research demonstrates a substantial and diverse academic presence, though it may be dispersed across numerous platforms rather than concentrated in a few prominent sources.

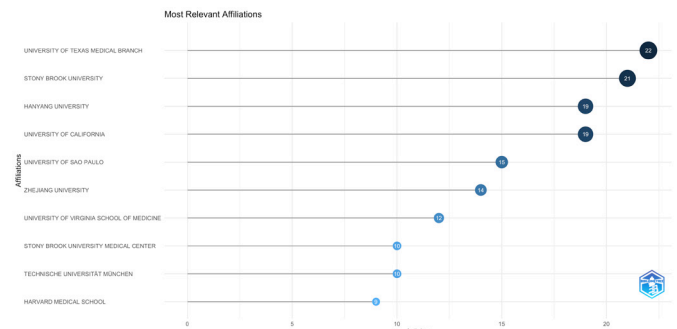


Figure 7. Most relevant affiliations

The citation counts for the papers on comb burns show a diverse range of impact among different authors. Regas and Ehrlich,<sup>1</sup> leads with 106 citations, indicating significant influence in the field. Authors such as Fang et al.<sup>6</sup> (104 citations) and Singer et al.<sup>7</sup> (with multiple entries ranging from 18 to 53 citations) also show considerable impact, reflecting their contributions to advancing research on comb burns. Other notable contributors include Nisanci<sup>8</sup> (34 citations), S. Oksuz<sup>9</sup> (34 citations), and X. Guo (33 citations), demonstrating their important role in the academic discourse.<sup>1,6-10</sup> Several authors, including Hayati et al.<sup>11</sup> (54 citations) and Ponticorvo et al.<sup>12</sup> (39 citations), also have substantial citations, underscoring their contributions.<sup>11,12</sup>

### Most Relevant Keywords

Figures 8 and 9 provide insights into the most frequently used keywords in comb burn research. Figure 8, a word cloud, highlights the prominence of terms such as “animal,” “models,” “disease,” “male,” “rats,” “Sprague Dawley,” “Wistar albino,” and “progression.” These keywords reflect the focus on animal models, particularly rats, in studying comb burns and disease progression. Figure 8, a table of the most relevant words, corroborates this by listing “animals,” “rats,” “disease models animal,” and “male” as the top terms.

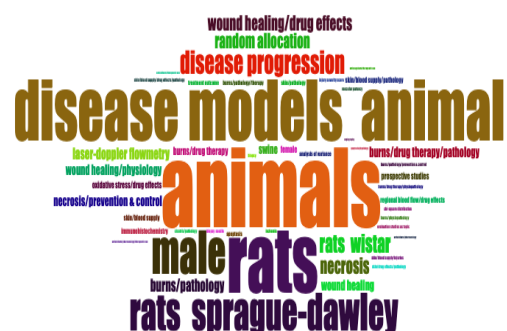


Figure 8. Word cloud of articles

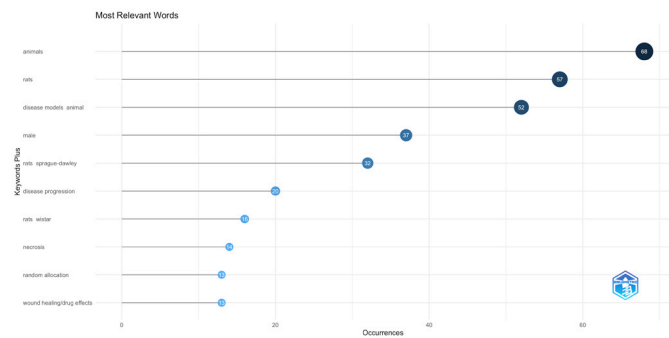


Figure 9. Most relevant words

### Countries Contributions

Figure 10 illustrates the scientific production of comb burn research by country. The figure highlights that the United States is the leading contributor, followed by China and Turkiye, indicating strong research activity and focus in these nations. Other countries such as Switzerland, Brazil, Korea and Iran also show significant contributions. Figure 11, which analyzes the contribution of countries by years, demonstrates an increase in the number of publications and the countries that have contributed to them, particularly in recent years. While the USA maintains its leading position, there has been a notable surge in the total number of publications and a rise in global interest in the subject matter, largely due to the contributions of China and Korea.

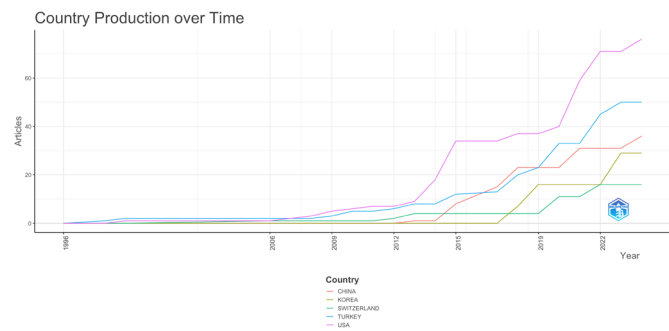


Figure 10. Country production over time

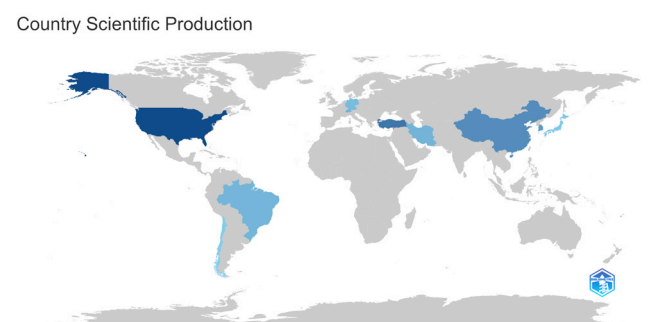


Figure 11. Country scientific production

## DISCUSSION

The bibliometric analysis of comb burn research reveals several key trends and insights that reflect the evolution and current state of the field.

### Publication Trends

The fluctuating annual output of comb burn research from 1992 to 2024 indicates varying levels of interest and advancements over time. Early intermittent activity suggests initial exploratory phases, while the gradual increase post-

2007 and peaks in 2013 and subsequent years highlight periods of intensified research focus. This trend suggests that while significant progress has been made, ongoing research and innovation are crucial to fully understand and address the complexities of comb burn injuries.

### Core Journals and Influential Sources

The identification of “Burns: Journal of the International Society for Burn Injuries” and the “Journal of Burn Care & Research” as core sources underscores their pivotal roles in disseminating key findings. The prominence of these journals suggests that researchers and practitioners in the field rely heavily on these sources for the latest developments. The steep decline in articles beyond these core journals highlights the concentrated nature of impactful research within a few specialized publications, reinforcing the importance of these journals in advancing comb burn knowledge.

### Key Authors and Contributions

The consistent contributions of leading authors such as Singer et al.,<sup>7</sup> as illustrated in Figures 5 and 6, demonstrate the sustained efforts and significant impact of these researchers. Their prolific output and long-term (over a decade) involvement highlight their dedication and the central role they play in advancing comb burn research. This consistency in contributions is vital for the continuous development of the field, providing a solid foundation upon which future research can build.

### Focus on Animal Models

The prominence of keywords related to animal models, particularly rats, in Figures 8 and 9, reflects the heavy reliance on these models for studying comb burns and disease progression. While rats provide valuable insights due to their physiological similarities to humans, the challenges posed by their rapid healing and high contracture rates highlight the need for cautious interpretation of results.<sup>13</sup> This focus also underscores the importance of refining animal models to better mimic human burn injuries, thereby improving the translational potential of research findings.

### International Contributions

The analysis of country contributions (Figures 10, 11) reveals that the United States, China, and Turkiye are leading contributors to comb burn research. This international distribution of research efforts signifies a global interest in addressing the complexities of burn injuries.<sup>14</sup> The notable surge in publications from China and Korea in recent years indicates a growing research capacity and focus in these countries, contributing to the global body of knowledge and fostering international collaboration.

### Methodological Variability and Standardization

The variability in methodology, particularly in the application times and temperatures of the comb burn model, as noted in the introduction, highlights a critical area for improvement. Standardizing these parameters is essential for ensuring consistency and comparability across studies. Addressing these methodological gaps will enhance the reliability and accuracy of research findings, ultimately leading to more effective treatments and better patient outcomes.

The field of comb burn research has attracted significant interest on a global scale, particularly in countries where

burn injuries are prevalent and present distinctive healthcare challenges. Researchers from regions including Southeast Asia, the Middle East and parts of Europe have demonstrated a notable interest in advancing knowledge on comb burns, recognizing the necessity for specialized approaches to both acute and long-term care.<sup>15</sup> Furthermore, leading journals in the fields of burn care and trauma, such as the *Journal of Burn Care & Research* and the *Burns* journal, regularly publish studies on comb burns, thereby underscoring the significance and visibility of this research area. The focus of these journals on comb burn injuries serves to underscore the global interest in this area and to acknowledge the specific clinical demands that these injuries pose. This, in turn, advocates for the allocation of more dedicated resources and for further research support.<sup>16</sup>

Furthermore, the increasing trends in comb burn research indicate a continued gap and growing potential for further exploration in this field. This upward trend suggests that while significant progress has been made, there are still many aspects of comb burns – such as wound healing, infection prevention, and rehabilitation – that remain underexplored or open for innovation.<sup>17</sup> Recent studies addressing topics such as burn care protocols, novel wound dressings and the psychological impacts of comb burns serve to reinforce the active research landscape and demonstrate that there are significant opportunities for advancement, particularly in the areas of improving patient outcomes and reducing the morbidity associated with comb burns.<sup>18</sup> This evolving field encourages both basic and applied research, indicating a promising path for future discoveries and improvements in care.

## CONCLUSION

The bibliometric analysis of comb burn research offers valuable insights into the evolution, current state, and future directions of the field. This study underscores several key points that can guide future research and enhance the overall understanding and treatment of burn injuries.

Bibliometric analysis serves as a powerful tool to map the research landscape, identify trends, and highlight influential contributions in a specific field. By systematically analyzing publication trends, author contributions, journal impact, and research networks, this study provides a comprehensive overview of the development and progression of comb burn research. The ability to visualize these trends and collaborations helps to pinpoint areas of strength and identify gaps that need addressing, thus guiding future research efforts.

To further advance the field of comb burn research, it is crucial to address the identified gaps and challenges. Standardizing methodologies, particularly in the application of the comb burn model, will enhance the reliability of research findings. Continued international collaboration and integration of diverse expertise will drive progress and innovation. Additionally, refining animal models to better replicate human burn injuries will improve the translational potential of research, leading to more effective treatments and improved patient care.

In conclusion, this bibliometric analysis provides a comprehensive overview of comb burn research, highlighting

key trends, influential contributions, and areas for improvement. By leveraging these insights, researchers and practitioners can guide future efforts to better understand and treat burn injuries, ultimately enhancing patient outcomes.

## ETHICAL DECLARATIONS

### Ethics Committee Approval

There are no ethical approval was required for this bibliometric analysis.

### Informed Consent

There are no ethical approval was required for this bibliometric analysis.

### Referee Evaluation Process

Externally peer-reviewed.

### Conflict of Interest Statement

The authors have no conflicts of interest to declare.

### Financial Disclosure

The authors declared that this study has received no financial support.

### Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

## REFERENCES

1. Regas FC, Ehrlich HP. Elucidating the vascular response to burns with a new rat model. *J Trauma*. 1992;32(5):557-563. doi:10.1097/00005373-199205000-00004
2. Jackson DM. The diagnosis of the depth of burning. *Br J Surg*. 1953; 40(164):588-96. doi:10.1002/bjs.18004016413
3. Morarasu S, Morarasu BC, Ghețu N, Dimofte MG, Iliescu R, Pieptu D. Experimental models for controlled burn injuries in rats: a systematic analysis of original methods and burn devices. *J Burn Care Res*. 2022;43(5):1055-1065. doi: 10.1093/jbcr/irab234
4. Smith RD Jr, Carney BC, Garg G, et al. Modeling burn progression using comb burns: the impact of thermal contact duration on model outcomes. *J Surg Res*. 2021;260:155-162. doi:10.1016/j.jss.2020.11.068
5. Tobalem M, Wettstein R, Tschanz E, et al. The burn comb model revisited. *Burns*. 2020;46(3):675-681. doi:10.1016/j.burns.2019.09.011
6. Fang Q, Guo S, Zhou H, Han R, Wu P, Han C. Astaxanthin protects against early burn-wound progression in rats by attenuating oxidative stress-induced inflammation and mitochondria-related apoptosis. *Sci Rep*. 2017;7:41440. doi: 10.1038/srep41440
7. Singer AJ, Taira BR, Lin F, et al. Curcumin reduces injury progression in a rat comb burn model. *J Burn Care Res*. 2011;32(1):135-142. doi: 10.1097/BCR.0b013e318203337b
8. Nisanci M, Eski M, Sahin I, Ilgan S, Isik S. Saving the zone of stasis in burns with activated protein C: an experimental study in rats. *Burns*. 2010;36(3):397-402. doi:10.1016/j.burns.2009.06.208
9. Öksüz S, Ülkür E, Öncül O, Köse GT, Küçükodac Z, Urhan M. The effect of subcutaneous mesenchymal stem cell injection on stasis zone and apoptosis in an experimental burn model. *Plast Reconstr Surg*. 2013;131(3):463-471. doi:10.1097/PRS.0b013e31827c6d6f
10. Guo SX, Jin YY, Fang Q, et al. Beneficial effects of hydrogen-rich saline on early burn-wound progression in rats. *PLoS One*. 2015;10(4):e0124897. doi:10.1371/journal.pone.0124897
11. Hayati F, Ghamsari SM, Dehghan MM, Oryan A. Effects of carbomer 940 hydrogel on burn wounds: an in vitro and in vivo study. *J Dermatolog Treat*. 2018;29(6):593-599. doi:10.1080/09546634.2018.1426823
12. Ponticorvo A, Burmeister DM, Rowland R, et al. Quantitative long-term measurements of burns in a rat model using spatial frequency domain imaging (SFDI) and laser speckle imaging (LSI). *Lasers Surg Med*. 2017;49(3):293-304. doi:10.1002/lsm.22647

13. Isik A, Memis U. Invited commentary: the efficacy of VAMMFT compared to “bogota bag” in achieving sheath closure following temporary abdominal closure at index laparotomy for trauma. *World J Surg.* 2023;47(6):1442-1443. doi:10.1007/s00268-023-06931-8
14. Işık A, Fırat D. Letter to the editor concerning most cited 100 articles from Turkiye on abdominal wall hernias: a bibliometric study. *Turk J Surg.* 2021;37(2):193-194. doi:10.47717/turkjsurg.2021.4973
15. Handayani E, Wahyuningtyas ES, Nugroho HP. A scoping review of burn care in Southeast Asia. *British Journal of Community Nursing.* 2023;28(Sup3):S24-S34. doi:10.12968/bjcn.2023.28.Sup3.S24
16. Smith RD, Jr, Carney BC, Garg G, et al. Modeling burn progression using comb burns: the impact of thermal contact duration on model outcomes. *J Surg Res.* 2021;260:155-162. doi: 10.1016/j.jss.2020.11.068
17. Rowan MP, Cancio LC, Elster EA, et al. Burn wound healing and treatment: review and advancements. *Critical Care.* 2015;19(1):243. doi: 10.1186/s13054-015-0961-2
18. Barajas-Nava LA, López-Alcalde J, Roqué i Figuls M, Solà I, Bonfill Cosp X. Antibiotic prophylaxis for preventing burn wound infection. *Cochrane Database Syst Rev.* 2013;2013(6):CD008738. doi: 10.1002/14651858.CD008738.pub2