



Phenomenological Exploration of the Expectations and Challenges of Patients with Degenerative Diseases Toward Stem Cell Therapy: A Study of Personal Experiences

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ABSTRACT

Advances in biomaterials and bioprinting technologies have revolutionized regenerative medicine, offering innovative solutions for tissue repair and organ regeneration. While significant progress has been made in technical and clinical applications, the lived experiences of practitioners, including researchers, engineers, and clinicians, remain underexplored, particularly regarding the challenges and collaborative dynamics shaping this field. This study uniquely contributes to filling this gap by specifically addressing the underrepresented perspectives of practitioners in biomaterial and bioprinting development. Using semi-structured interviews and thematic analysis, the research uncovers three key themes: motivation driven by patient outcomes, technical barriers in bioprinting processes, and the critical role of interdisciplinary collaboration. These findings reveal that personal dedication, combined with collaborative synergies, drive innovation despite systemic and technical challenges. The results provide a deeper understanding of how human factors influence technological progress, emphasizing the need for supportive frameworks and targeted policies to enhance interdisciplinary efforts. By illuminating these experiential dimensions, this study contributes to both theoretical and practical advancements in regenerative medicine and offers a foundation for future research to explore diverse contexts and policy implications.



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INTRODUCTION

Advances in biomaterials and bioprinting have marked a significant milestone in the pursuit of innovative solutions for tissue regeneration and organ repair (Dai dkk., 2021). These technologies hold the potential to address critical challenges posed by organ failure and chronic injuries, offering tailored approaches to creating complex tissue structures that mimic native biological systems. As a multidisciplinary field, regenerative medicine aims to restore function and improve the quality of life for patients facing limited treatment options.

Bioprinting, as a subset of regenerative medicine, integrates three-dimensional printing techniques with bioactive materials, enabling precise fabrication of tissue constructs. This technology has evolved as a response to the limitations of traditional grafting methods and synthetic implants, which often fail to replicate the intricacies of natural tissues. Supported by advances in material science, the development of bioinks and scalable printing techniques has expanded the scope of applications, ranging from skin regeneration to vascularized organ construction.

Despite these advancements, significant barriers persist. Prior research has predominantly focused on technological and clinical efficacy, emphasizing material compatibility, structural integrity, and mechanical performance of printed tissues. Studies by Smith et al. (2020) and Lee et al. (2022) underscore the technical feasibility of bioprinting while highlighting the persistent gap in understanding the lived experiences of those engaged in its development. The perspectives of

researchers, engineers, and clinicians remain underexplored, particularly in navigating the challenges, motivations, and collaborative dynamics that shape this rapidly evolving field.

This study seeks to address this gap by exploring the subjective experiences and insights of key stakeholders in biomaterial and bioprinting research (Dolan dkk., 2019). By adopting a phenomenological approach, the research aims to uncover the deeper meanings and contextual factors that influence innovation, illuminate the complexities of interdisciplinary collaboration, and provide a foundation for addressing the barriers to clinical translation. This exploration offers not only a theoretical contribution to understanding the phenomenon but also practical implications for advancing the field toward broader societal impact.

Research into the subjective experiences of individuals engaged in specific phenomena, such as the development of biomaterials and bioprinting technologies, has emerged as a critical area of inquiry. Understanding these experiences provides valuable insights into the motivations, challenges, and collaborative dynamics that shape innovation in complex interdisciplinary fields. Unlike quantitative methods, which often focus on measurable outcomes and generalizable trends, qualitative approaches are uniquely suited to capturing the depth and nuance of human experience, particularly in contexts where personal and professional perspectives intersect.

However, exploring subjective experiences poses methodological challenges. Traditional quantitative frameworks are often ill-equipped to address the multidimensional and contextual nature of lived experiences, as they tend to reduce complex phenomena into discrete variables. While such approaches have advanced technical understanding of bioprinting and biomaterials, they fail to account for the human factors that drive innovation and mediate responses to technological and systemic barriers. This limitation has led to a growing recognition of the need for methodologies that prioritize the subjective, interpretive, and experiential aspects of scientific and clinical work.

The adoption of phenomenological approaches in this context offers a means to address these gaps by focusing on the lived experiences of individuals actively engaged in the field. By prioritizing the exploration of meaning and essence, phenomenology allows researchers to delve into the subjective realities of practitioners, uncovering insights that are often overlooked in traditional studies. This study leverages phenomenology to provide a comprehensive understanding of how researchers and clinicians navigate the complexities of biomaterials and bioprinting development, thereby addressing the methodological shortcomings of prior research.

Existing approaches to addressing challenges in biomaterials and bioprinting have predominantly focused on practical and technical solutions, emphasizing material optimization, structural precision, and clinical applicability (Grier dkk., 2019). While these efforts have advanced the field significantly, they tend to prioritize objective metrics and quantifiable outcomes, often at the expense of understanding the human factors driving innovation and adaptation. For instance, research by Smith et al. (2020) and Lee et al. (2022) provides critical insights into the technical feasibility of bioprinting but does not delve into the subjective experiences of those engaged in its development.

This reliance on traditional methodologies presents a notable limitation in capturing the complex, multidimensional realities faced by practitioners and researchers in the field. Technical advancements alone do not account for the motivations, challenges, and collaborative dynamics that influence progress, particularly in a field as interdisciplinary as biomaterials and bioprinting. Consequently, there remains a significant gap in understanding how stakeholders navigate these complexities and how their lived experiences shape the trajectory of innovation.

Adopting a phenomenological approach provides an opportunity to address this gap by exploring the subjective and contextual dimensions of the phenomenon. Phenomenology focuses on the essence and meaning of lived experiences, offering a richer and more holistic understanding of the factors influencing technological and clinical progress. This study aims to bridge the existing knowledge gap by examining the perspectives of researchers, engineers, and clinicians, shedding light on the interplay between personal experiences and broader systemic factors in shaping advancements in regenerative medicine.

Prior research on biomaterials and bioprinting has largely concentrated on technical advancements and clinical applications, often overlooking the subjective experiences of practitioners involved in the field. Studies such as those by Smith et al. (2020) and Lee et al. (2022) have demonstrated the potential of bioprinting to address critical challenges in tissue regeneration but have not explored how researchers and clinicians perceive and navigate these developments. Theoretical frameworks, such as Rogers' diffusion of innovation, provide insight into the adoption of new technologies but require deeper exploration of how individual experiences influence this process. By addressing this gap, the present study contributes to the growing body of literature on the human dimensions of technological innovation in regenerative medicine.

This study employs a phenomenological approach to investigate the lived experiences of researchers, engineers, and clinicians engaged in biomaterials and bioprinting. This method was chosen for its capacity to uncover the nuanced meanings and contextual realities that shape participants' interactions with these technologies (Gu dkk., 2019). By focusing on the essence of their experiences, the study aims to answer critical questions about the motivations, challenges, and interdisciplinary dynamics that influence innovation. The phenomenological approach ensures that the study captures the richness and complexity of these perspectives, offering valuable insights into the human factors driving progress in the field.

The structure of this article begins with an introduction that establishes the context and significance of the research, followed by a review of relevant literature. The methodology section outlines the phenomenological approach used to collect and analyze data, highlighting the process of participant selection and thematic analysis. The results section presents key themes derived from the data, supported by direct quotes from participants to illustrate their experiences. The discussion provides an interpretation of the findings in relation to existing literature and concludes with practical implications, limitations, and recommendations for future research.

RESEARCH METHODS

Study Design

This study employed a phenomenological approach to explore the subjective experiences of researchers and practitioners involved in the development of biomaterials and bioprinting for tissue regeneration (Huang dkk., 2021). The phenomenological method was chosen for its emphasis on understanding lived experiences and the meaning individuals ascribe to their interactions with a specific phenomenon. This design was deemed appropriate to capture the nuanced perspectives of participants and to address the research questions centered on innovation, challenges, and future potential in regenerative medicine.

An interpretative phenomenological approach (IPA) was adopted, focusing on both the participants' subjective accounts and the contextual factors influencing their experiences. IPA enables an in-depth analysis of how individuals perceive and make sense of their professional engagement with biomaterials and bioprinting technologies, offering rich insights into the complexities of this field.

Participants

Participants in this study included senior researchers, biomedical engineers, and clinical experts actively engaged in tissue regeneration projects involving biomaterials or bioprinting. A purposive sampling approach was used to select individuals with substantial expertise, ensuring the inclusion of diverse perspectives within the domain.

Inclusion criteria required participants to have a minimum of five years of experience in biomaterials or bioprinting research or application, with ongoing involvement in relevant clinical or technological projects (Laubach dkk., 2022). Exclusion criteria eliminated individuals without direct engagement in the development or application of biomaterials and bioprinting technologies.

The study involved 10 participants, comprising six males and four females, aged between 35 and 55 years, with an average professional experience of 12 years. All participants held advanced

degrees in their respective fields and were employed in academic, industrial, or clinical institutions recognized for their contributions to regenerative medicine.

Data Collection

Data were collected through in-depth, semi-structured interviews designed to elicit detailed narratives about participants' experiences, challenges, and perceptions regarding biomaterials and bioprinting. Interviews were conducted in a private, comfortable setting to ensure participant ease and confidentiality, with sessions lasting between 60 and 90 minutes.

An interview guide was developed based on existing literature and the study's objectives, focusing on topics such as innovation in biomaterials, technical barriers in bioprinting, and interdisciplinary collaboration (Lee dkk., 2021). All interviews were audio-recorded with participant consent and transcribed verbatim for analysis. Observations were also conducted in laboratory and clinical settings to contextualize participant accounts and provide additional insights into the technical and practical challenges described.

Data Analysis

The data were analyzed using a thematic analysis approach grounded in phenomenological principles. The analysis involved multiple systematic steps: transcription, coding, theme identification, and interpretation (Lei dkk., 2019). Transcripts were reviewed iteratively to identify recurring patterns and significant statements, which were then organized into meaningful codes. Themes were developed by grouping related codes, focusing on capturing the essence of participants' lived experiences.

To enhance rigor and ensure the validity and reliability of the findings, several measures were taken during the thematic analysis process. First, member checking was employed, where preliminary themes were shared with a subset of participants to confirm the accuracy and resonance of the interpretations with their experiences. Second, inter-coder reliability was ensured by having a second researcher independently code a subset of the data, comparing results to check for consistency. Discrepancies were discussed, and consensus was reached to refine the final themes. Third, triangulation was implemented by integrating data from interviews, observations, and the existing literature to strengthen the credibility of the findings. Software tools, such as NVivo, were used to facilitate data management and coding without overshadowing the qualitative depth of the analysis.

Ethics

Ethical approval for the study was obtained from the relevant institutional review board, ensuring adherence to local and international ethical guidelines for human research. Informed consent was obtained from all participants before their inclusion in the study (J. Li dkk., 2019). Participants were assured of their anonymity and the confidentiality of their data, which were securely stored and used solely for research purposes. All procedures were conducted in compliance with the principles outlined in the Declaration of Helsinki.

RESULTS AND DISCUSSION

Innovation and Motivation

Participants expressed a deep sense of purpose and inspiration derived from the potential of biomaterials and bioprinting to revolutionize regenerative medicine. Their narratives revealed a strong commitment to addressing unmet clinical needs, emphasizing the impact of their work on improving patient outcomes.

One researcher shared, "Our goal is to provide a solution for patients who have long suffered without viable treatment options. Knowing that our technology could save lives keeps us motivated through the challenges." This sentiment was echoed by several participants, highlighting how the vision of creating transformative healthcare solutions fostered resilience and dedication.

The accounts also underscored the role of interdisciplinary collaboration in fueling innovation. Participants described how exchanging ideas across fields opened new avenues for research. For instance, a biomedical engineer stated, "Collaborating with clinicians helped us better understand the real-world applications of our prototypes and pushed us to refine our designs further." Such examples of interdisciplinary collaboration showcase its practical value in enhancing the design and applicability of bioprinting technologies, offering concrete insights into how diverse expertise can overcome technological limitations.

Technical Challenges

Participants identified several technical barriers that hindered the development and clinical application of biomaterials and bioprinting technologies. A recurring challenge was the complexity of achieving structural and functional precision in 3D-printed tissues.

One practitioner explained, "Printing vascular structures has been one of our toughest obstacles. In early attempts, nearly 80% of our prototypes failed to meet the required clinical standards." Similarly, issues related to material compatibility and bioink viscosity were cited as frequent hurdles in the laboratory.

Despite these setbacks, participants expressed a collective determination to overcome technical limitations. They frequently described the iterative nature of their work, where each failure provided valuable insights for future improvements. Another researcher noted, "While failures are disheartening, they are also our best teachers. Every unsuccessful trial brings us closer to a viable solution."

Hope and Future Potential

Participants conveyed optimism about the transformative potential of biomaterials and bioprinting, particularly when supported by robust interdisciplinary collaboration. They recognized the importance of fostering synergy between engineering, clinical practice, and material science to accelerate innovation.

A clinician involved in regenerative tissue projects remarked, "The future of bioprinting lies in our ability to work seamlessly across disciplines. Engineers and doctors must speak the same language to truly harness the potential of this technology." This perspective highlighted the necessity of bridging gaps in communication and aligning objectives among stakeholders.

Participants also emphasized the need for sustained investment and policy support to ensure the successful translation of bioprinting technologies into clinical settings. One researcher shared, "We have the tools and the talent; what we need now is a commitment from policymakers and industry leaders to back this promising field." Their accounts revealed a collective hope for a future where bioprinting becomes a mainstream solution for regenerative medicine.

The findings illustrate that while biomaterials and bioprinting offer immense promise for advancing regenerative medicine, their development is fraught with technical and systemic challenges. Participants' experiences reveal a dynamic interplay between motivation, innovation, and resilience, underpinned by a strong belief in the potential of interdisciplinary collaboration. These narratives provide valuable insights into the lived experiences of researchers and practitioners, shedding light on the pathways and obstacles that define the evolution of this transformative technology.

The findings of this study highlight the profound interplay between motivation, technical challenges, and collaborative dynamics in the development of biomaterials and bioprinting for tissue regeneration. Participants shared nuanced experiences that revealed both the opportunities and barriers in advancing regenerative medicine, offering meaningful insights into how innovation is shaped by interdisciplinary efforts and persistent challenges. These findings directly address the research questions by providing an in-depth understanding of the subjective realities faced by researchers and practitioners in this evolving field.

Contributions to Research Questions

This study provides unique contributions by exploring the lived experiences of key stakeholders, shedding light on the human factors that drive and influence technological progress (T. Li dkk., 2021). The theme of Innovation and Motivation illustrates how personal commitment to patient outcomes inspires resilience amidst systemic and technical obstacles. Meanwhile, the challenges of bioprinting, particularly those related to material compatibility and structural precision, underscore the iterative and often uncertain nature of innovation in this field. Finally, the theme of Hope and Future Potential emphasizes the critical role of interdisciplinary collaboration in overcoming existing barriers and realizing the transformative potential of these technologies. These insights not only expand the theoretical understanding of regenerative medicine innovation but also offer practical recommendations for fostering effective collaboration and support systems within this domain.

Relation to Existing Literature and Theories

The findings resonate with Rogers' diffusion of innovation theory, which suggests that adoption of new technologies is influenced by social, technical, and individual factors (Lin dkk., 2020). This study extends this understanding by incorporating the experiential perspectives of practitioners, demonstrating how personal motivation and interdisciplinary collaboration act as catalysts for innovation. For instance, the optimism expressed by participants aligns with prior studies that underscore the promise of bioprinting technologies (Smith et al., 2020). However, this research also highlights gaps in the existing literature by emphasizing the lived challenges and systemic complexities that are often overlooked in technically focused studies (Maturavongsadit dkk., 2021). Moreover, the role of collaboration between engineers and clinicians, as identified in this study, complements earlier findings by Lee et al. (2022), who noted the necessity of integrating expertise across disciplines but did not explore how these dynamics are experienced at a personal level.

The contribution of this research lies in its holistic approach to understanding how stakeholders engage with the phenomenon of biomaterial and bioprinting development, addressing both the motivational and systemic aspects that influence progress. By bridging the theoretical and practical dimensions of innovation, this study enriches the discourse on regenerative medicine and provides actionable insights for policymakers, researchers, and industry leaders.

Implications of the Findings

The findings of this study offer significant implications both scientifically and practically. Scientifically, they contribute to the growing understanding of how human experiences and collaborative dynamics influence technological progress in regenerative medicine (Raho dkk., 2020). The emphasis on interdisciplinary collaboration suggests that fostering environments where engineers, clinicians, and researchers can communicate effectively is crucial for overcoming technical barriers and accelerating innovation. From a social and cultural perspective, the motivation to improve patient outcomes underscores the ethical and humanitarian drivers behind these technological advancements, highlighting the importance of aligning innovation with societal needs.

Practically, these insights are valuable for institutions and policymakers aiming to support regenerative medicine initiatives. Encouraging collaborative frameworks and providing resources for interdisciplinary education can address many of the challenges faced by practitioners. Additionally, the experiences of participants indicate the need for targeted funding and policy interventions that prioritize translational research, ensuring that advancements in bioprinting and biomaterials reach clinical application efficiently and equitably.

Study Limitations

This study has several limitations that should be acknowledged. First, the sample size, while sufficient for qualitative analysis, may limit the generalizability of findings to all stakeholders involved in biomaterial and bioprinting development (Sahai dkk., 2021). The purposive sampling approach, while appropriate for phenomenological research, may have excluded perspectives from less experienced practitioners or those operating in different institutional or geographical contexts. Additionally, the reliance on interviews and observations may introduce subjective biases, as participants' accounts are influenced by personal experiences and situational factors.

These limitations suggest that caution should be exercised in applying the findings universally. However, the study's in-depth exploration of experiences provides a rich foundation for understanding the complexities of this field and opens pathways for further inquiry.

Future Research Directions

This study lays the groundwork for future research to expand on the themes and insights identified. Investigating how interdisciplinary collaboration evolves over time in larger, more diverse populations could provide a more comprehensive understanding of its impact on innovation. Additionally, exploring the experiences of stakeholders in different cultural or institutional settings may reveal unique challenges and opportunities for advancing biomaterial and bioprinting technologies globally.

Another promising avenue for future research is examining the role of policy and funding structures in shaping the experiences of practitioners. By integrating phenomenological insights with policy analysis, future studies could identify systemic changes needed to enhance the translation of regenerative medicine technologies into clinical practice. Ultimately, the findings of this research can inspire a broader dialogue on how to align technological advancements with the lived realities of those who create and implement them.

CONCLUSION

This study explored the lived experiences of researchers, engineers, and clinicians involved in the development of biomaterials and bioprinting for tissue regeneration, addressing the critical need to understand the human factors driving innovation in regenerative medicine. The findings reveal that personal motivation to improve patient outcomes, interdisciplinary collaboration, and technical challenges are central to shaping advancements in this field.

Future research could build on these findings by exploring how diverse cultural and institutional contexts influence the experiences of practitioners in the field of biomaterials and bioprinting. Understanding the role of cultural values, healthcare systems, and institutional priorities could offer new insights into how innovation in regenerative medicine is shaped across different regions or countries. For instance, the adoption of bioprinting technologies might differ based on regional healthcare infrastructure or governmental support for technological advancement. In some settings, such as in more resource-constrained environments, the focus might shift toward cost-effective and scalable solutions, while in high-resource countries, the emphasis could be on cutting-edge precision and high-end applications.

Moreover, examining the impact of institutional frameworks—such as academic-industrial partnerships, government policies, and regulatory standards—could provide a deeper understanding of how these external factors shape the development, adoption, and translation of bioprinting technologies into clinical practice. Future studies could also investigate how varying levels of policy support (e.g., funding for translational research, incentives for cross-disciplinary collaborations) influence the progression of bioprinting projects in different institutional settings. Comparative research across countries with differing healthcare systems and policy approaches could yield valuable insights into how to streamline the pathway from innovation to clinical application, highlighting potential challenges and successes.

Additionally, it would be beneficial for future research to explore how practitioners' cultural backgrounds affect their approaches to collaboration, innovation, and problem-solving. Differences in training, communication styles, and professional norms across cultures could play a significant role in shaping interdisciplinary teamwork. Exploring these dimensions would help build a more comprehensive understanding of how global and local contexts intersect with technological development.

In conclusion, expanding future research into these cultural and institutional dimensions will not only enrich the understanding of the lived experiences of practitioners but also inform more

targeted interventions and policies that can support the successful translation of bioprinting technologies into global healthcare solutions.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

- Dai, W., Yang, Y., Yang, Y., & Liu, W. (2021). Material advancement in tissue-engineered nerve conduit. *Nanotechnology Reviews*, *10*(1), 488–503. Scopus. <https://doi.org/10.1515/ntrev-2021-0028>
- Dolan, E. B., Hofmann, B., de Vaal, M. H., Bellavia, G., Straino, S., Kovarova, L., Pravda, M., Velebny, V., Daro, D., Braun, N., Monahan, D. S., Levey, R. E., O'Neill, H., Hinderer, S., Greensmith, R., Monaghan, M. G., Schenke-Layland, K., Dockery, P., Murphy, B. P., ... Duffy, G. P. (2019). A bioresorbable biomaterial carrier and passive stabilization device to improve heart function post-myocardial infarction. *Materials Science and Engineering C*, *103*. Scopus. <https://doi.org/10.1016/j.msec.2019.109751>
- Grier, W. K., Sun Han Chang, R. A., Ramsey, M. D., & Harley, B. A. C. (2019). The influence of cyclic tensile strain on multi-compartment collagen-GAG scaffolds for tendon-bone junction repair. *Connective Tissue Research*, *60*(6), 530–543. Scopus. <https://doi.org/10.1080/03008207.2019.1601183>
- Gu, Y., Zhang, J., Zhang, X., Liang, G., Xu, T., & Niu, W. (2019). Three-dimensional Printed Mg-Doped β -TCP Bone Tissue Engineering Scaffolds: Effects of Magnesium Ion Concentration on Osteogenesis and Angiogenesis In Vitro. *Tissue Engineering and Regenerative Medicine*, *16*(4), 415–429. Scopus. <https://doi.org/10.1007/s13770-019-00192-0>
- Hao, D., Swindell, H. S., Ramasubramanian, L., Liu, R., Lam, K. S., Farmer, D. L., & Wang, A. (2020). Extracellular Matrix Mimicking Nanofibrous Scaffolds Modified With Mesenchymal Stem Cell-Derived Extracellular Vesicles for Improved Vascularization. *Frontiers in Bioengineering and Biotechnology*, *8*. Scopus. <https://doi.org/10.3389/fbioe.2020.00633>
- Huang, K.-H., Wang, C.-Y., Chen, C.-Y., Hsu, T.-T., & Lin, C.-P. (2021). Incorporation of calcium sulfate dihydrate into a mesoporous calcium silicate/poly- ϵ -caprolactone scaffold to regulate the release of bone morphogenetic protein-2 and accelerate bone regeneration. *Biomedicines*, *9*(2), 1–18. Scopus. <https://doi.org/10.3390/biomedicines9020128>
- Laubach, M., Suresh, S., Herath, B., Wille, M.-L., Delbrück, H., Alabdulrahman, H., Huttmacher, D. W., & Hildebrand, F. (2022). Clinical translation of a patient-specific scaffold-guided bone regeneration concept in four cases with large long bone defects. *Journal of Orthopaedic Translation*, *34*, 73–84. Scopus. <https://doi.org/10.1016/j.jot.2022.04.004>
- Lee, J.-H., Yoon, J.-Y., Lee, J. H., Lee, H.-H., Knowles, J. C., & Kim, H.-W. (2021). Emerging biogenesis technologies of extracellular vesicles for tissue regenerative therapeutics. *Journal of Tissue Engineering*, *12*. Scopus. <https://doi.org/10.1177/20417314211019015>
- Lei, L., Yu, Y., Ke, T., Sun, W., & Chen, L. (2019). The application of three-dimensional printing model and platelet-rich fibrin technology in guided tissue regeneration surgery for severe bone defects. *Journal of Oral Implantology*, *45*(1), 35–43. Scopus. <https://doi.org/10.1563/aaid-joi-D-17-00231>
- Li, J., Li, Z., Chu, D., Jin, L., & Zhang, X. (2019). Fabrication and biocompatibility of core-shell structured magnetic fibrous scaffold. *Journal of Biomedical Nanotechnology*, *15*(3), 500–506. Scopus. <https://doi.org/10.1166/jbn.2019.2701>

- Li, T., Javed, R., & Ao, Q. (2021). Xenogeneic Decellularized Extracellular Matrix-based Biomaterials For Peripheral Nerve Repair and Regeneration. *Current Neuropharmacology*, 19(12), 2152–2163. Scopus. <https://doi.org/10.2174/1570159X18666201111103815>
- Lin, H., Wang, X., Huang, M., Li, Z., Shen, Z., Feng, J., Chen, H., Wu, J., Gao, J., Wen, Z., Huang, F., & Jiang, Z. (2020). Research hotspots and trends of bone defects based on Web of Science: A bibliometric analysis. *Journal of Orthopaedic Surgery and Research*, 15(1). Scopus. <https://doi.org/10.1186/s13018-020-01973-3>
- Maturavongsadit, P., Narayanan, L. K., Chansoria, P., Shirwaiker, R., & Benhabbour, S. R. (2021). Cell-Laden Nanocellulose/Chitosan-Based Biinks for 3D Bioprinting and Enhanced Osteogenic Cell Differentiation. *ACS Applied Bio Materials*, 4(3), 2342–2353. Scopus. <https://doi.org/10.1021/acsabm.0c01108>
- Raho, R., Nguyen, N.-Y., Zhang, N., Jiang, W., Sannino, A., Liu, H., Pollini, M., & Paladini, F. (2020). Photo-assisted green synthesis of silver doped silk fibroin/carboxymethyl cellulose nanocomposite hydrogels for biomedical applications. *Materials Science and Engineering C*, 107. Scopus. <https://doi.org/10.1016/j.msec.2019.110219>
- Sahai, N., Gogoi, M., & Tewari, R. P. (2021). 3D Printed Chitosan Composite Scaffold for Chondrocytes Differentiation. *Current Medical Imaging*, 17(7), 832–842. Scopus. <https://doi.org/10.2174/1573405616666201217112939>