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Retraction

Retracted: The Study of Expanded Polytetrafluoroethylene New Material in Dural Repair

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

1. Discrepancies in scope
2. Discrepancies in the description of the research reported
3. Discrepancies between the availability of data and the research described
4. Inappropriate citations
5. Incoherent, meaningless and/or irrelevant content included in the article
6. Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y.-Q. Xu, W.-B. Gao, M.-Y. Xing et al., "The Study of Expanded Polytetrafluoroethylene New Material in Dural Repair," *Journal of Nanomaterials*, vol. 2022, Article ID 4143413, 6 pages, 2022.

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Research Article

The Study of Expanded Polytetrafluoroethylene New Material in Dural Repair

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Dural defect is a common problem in neurosurgery, and the emergence of expanded polytetrafluoroethylene material provides an effective solution for the rehabilitation of artificial blood vessels, heart patches, and other fields. However, studies on the repair of expanded polytetrafluoroethylene in the dura have reported the occurrence of adverse events of cerebrospinal fluid leakage. Therefore, the task of improving expanded polytetrafluoroethylene materials cannot be delayed. In this study, a new composite dural repair material based on expanded polytetrafluoroethylene and polylactic acid-glycolic acid (expanded polytetrafluoroethylene/polylactic acid-glycolic acid) was designed and synthesized. The results of *in vivo* experiments confirmed that the material can fully meet the requirements of repairing the integrity of the dura mater, providing protection for the intracranial structure and rebuilding the extracellular matrix. More importantly, the new composite dural repair material can greatly reduce the incidence of cerebrospinal fluid leakage and inhibit inflammation. Therefore, the application data of this study on New Zealand rabbit species will lay an important foundation for the development of dural repair technology.

1. Introduction

The dura mater is a double membranous tissue structure between the inner surface of the skull and the brain tissue, which protects the intracranial brain tissue and stores cerebrospinal fluid [1–3]. According to reports, dural defects are not uncommon in neurosurgery, and they are an important factor in inducing cerebrospinal fluid leakage, intracranial infection, meningitis, encephalocele, and epilepsy. Therefore, a series of studies have been carried out for dural repair to reduce the risk of clinical treatment [4–7].

As the most important part of the repair operation, dural repair materials need to consider many factors. For example, the material implanted in the body can solve the problem of cerebrospinal fluid leakage in time, with good biological safety and histocompatibility; the adhesion of the implanted material to the brain tissue is less, and the raw materials are easy to obtain. Four kinds of dural repair materials are widely used in the clinic, including autologous tissue, allogeneic tissue, heterogeneous source materials, and artificial synthetic materials.

Since 1893, the patient's own fascia, peritoneum, and aponeurosis have been used in dural repair operations, and the results of the treatment have been satisfactory. The biggest advantage of autologous tissue as a repair material is that it will not produce immune rejection, but the limitations of the material itself greatly hinder its clinical application [8–11]. In addition, as an allogeneic tissue repair material, freeze-dried human cadaveric dura has been used in the repair of defective dura for many times. It is found that the material can completely retain the normal microstructure of human dura. However, some reports disclosed that adverse events such as brain atrophy, convulsions, dementia, hepatitis, and viral diseases occurred after dural repair surgery, which brought serious risks to clinical application [12–14]. In response to this limitation, heterogeneous source

materials (such as bovine and sheep pericardium and pig and sheep peritoneum) have been extensively explored in dural repair [15]. These materials are rich in sources and easy to prepare, but the chronic inflammatory response caused by residual aldehyde groups remains to be resolved. In recent years, artificial synthetic materials, such as bacterial cellulose membranes and collagen fiber patches, have begun to receive widespread attention. The artificially synthesized dural patch can meet the shape and size requirements for surgery, is convenient to obtain materials, and does not have the problem of potential virus infection. Its application prospects are promising, and it has great potential in dural replacement [16–19].

ePTFE is a kind of polymer material, which is modified by the expansion of polytetrafluoroethylene. It has excellent biocompatibility and special microporous structure. It is used in wound dressings, heart valves, artificial blood vessels, cosmetic plastic surgery, and other fields which have been successfully applied; it is an ideal biological tissue replacement material [20–23]. In addition, studies on ePTFE in dural repair surgery revealed that ePTFE filling can significantly increase the success rate of surgery and effectively reduce the occurrence of complications such as syringomyelia. However, ePTFE is prone to leakage of cerebrospinal fluid (CSF) in repair operations for larger gaps. Therefore, this work has made a lot of efforts to address this problem in order to provide convenience for the better application of ePTFE in clinical practice.

Polylactic acid-glycolic acid (PLGA) is a biodegradable polymer compound, which is polymerized by lactic acid and glycolic acid. It has been widely used as tissue engineering materials, implant materials, or drug carriers [24–27]. The use of PLGA can make up for the structural and performance defects of most materials to increase the penetration rate of existing materials. Based on the above background, this work effectively combines PLGA and ePTFE to design and synthesize a new type of composite dural repair material (ePTFE/PLGA).

Taking New Zealand rabbits as the experimental model, this study applied ePTFE/PLGA film to dural repair, systematically evaluated the effect of ePTFE/PLGA in dural repair, and provided theoretical support for clinical application. The research report is as follows.

2. Materials and Methods

2.1. Materials and Instruments. Polylactic acid-glycolic acid (PLGA) was purchased from Shandong Xinfu Industrial Co., Ltd. (Shandong, China). Dichloromethane (CH_2Cl_2) was purchased from Shandong Chuxin Chemical Co., Ltd. (Shandong, China). Dimethylformamide (C_3H_7NO) was purchased from Jinan Huijinchuan Chemical Co., Ltd. The medical expanded polytetrafluoroethylene (ePTFE) therapeutic filter membrane was purchased from Zhangjiagang City Lvhuan Machinery Co., Ltd. (Jiangsu, China). Ordinary adult New Zealand rabbits were purchased from Qingdao Zhongchuang Biotechnology Co., Ltd. (Shandong, China). Sodium pentobarbital ($C_{11}H_{17}N_2NaO_3$) was purchased from Shanghai Xinya Pharmaceutical Co., Ltd. (Shanghai, China). Penicillin sodium ($C_{16}H_{17}N_2NaO_4S$) was purchased from Hubei Huizepu Pharmaceutical Technology Co., Ltd. (Hubei, China). Sterile gauze was purchased from Caoxian Hualu Sanitary Materials Co., Ltd. (Shandong, China). Methylene blue ($C_{16}H_{18}N_3ClS$) was purchased from Beijing Wokai Biotechnology Co., Ltd. (Beijing, China). Ethanol (C_2H_6O) was purchased from Wuhan Jiuyi Chemical Co., Ltd. (Hubei, China). The ELISA kit was purchased from Jiangsu Jingmei Biotechnology Co., Ltd. (Jiangsu, China).

The high-temperature oven was purchased from Defei Ruisi Intelligent Drying Equipment Co., Ltd. (Jiangsu, China). The centrifuge was purchased from Shanghai Pudong Tianben Centrifugal Machinery Co., Ltd. (Shanghai, China). Zeiss Axio Vert.A1 inverted biological microscope and field emission scanning electron microscope were purchased from Carl Zeiss AG (Jena, Germany).

2.2. Preparation of New Materials. An appropriate amount of polylactic acid-glycolic acid was added to the mixed solvent of dichloromethane and dimethylformamide to obtain a PLGA solution (125 g/L). The PLGA solution was uniformly coated on the surface of ePTFE to form a film, dried in an oven at 80°C for 8.0 min, and then shaped in a setting machine at 150°C for 8 min. Finally, an ePTFE/PLGA film was obtained.

2.3. Construction of Dural Defect Model. Forty-two New Zealand rabbits were randomly divided into the operation group (ePTFE group and ePTFE/PLGA group) and the sham operation group according to their weight differences. 1.5% sodium pentobarbital was injected through the ear vein for anesthesia, and the limbs were fixed in the prone position. Before operation, each rabbit was injected with 8.0×10^5 U penicillin sodium intramuscularly. The surgical area is shaved, marked, and disinfected. Make a 5.0 cm longitudinal incision with the mark as the center, deep into the subcutaneous tissue, and then peel off the periosteum. Gradually remove the parietal bone, occipital bone, and part of the frontal bone on the posterior side of the coronal suture and on the side of the sagittal suture to form a 3.5×3.0 cm bone window. In the operation group, New Zealand rabbits were flushed and stopped thoroughly, and the dura mater on both sides of the superior sagittal sinus was removed by ophthalmic scissors, forming a 1.5×1.0 cm dural defect.

2.4. Treatment of Model Rabbits. After creating the dura mater defect, it is repaired with artificial dura mater. Briefly, the commercially available ePTFE membrane material was trimmed into a notch shape, and the dura mater of the ePTFE group model rabbit was repaired and fixed with sutures. Cut the ePTFE/PLGA composite film into a suitable shape, and use the same surgical method to repair the dura mater of the ePTFE/PLGA group model rabbits. Sterile gauze was used to cover and bandage the surgical site of the model rabbits, and the New Zealand rabbits were raised in a single cage after they regained consciousness. Starting from the first day after surgery, 4.0×10^5 U penicillin sodium was intramuscularly injected into all New Zealand rabbits to prevent infection, once in the morning and once

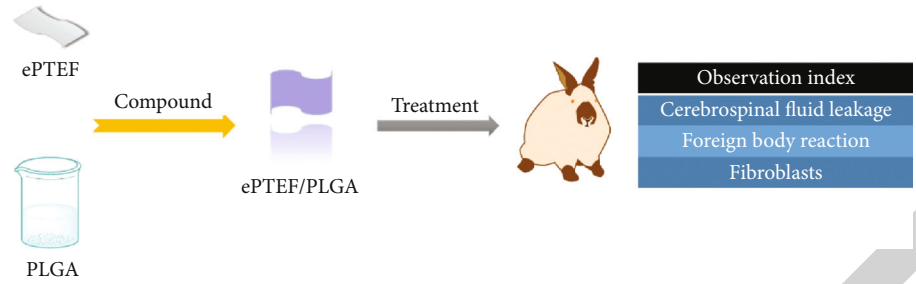

Figure 1: Preparation and application of new material.

in the evening. On the 9th day after the operation, the sutures were removed and the relevant indicators were observed (Figure 1).

2.5. Observation Indicators

2.5.1. Cerebrospinal Fluid Leakage. After the New Zealand rabbits in the surgical group were treated, a drill was used to drill a small hole in the 3.0 cm skull around the dura mater. Push the Milan solution along the scalp needle catheter into the subarachnoid space and observe the overflow of the Milan solution on the side.

2.5.2. Inflammation Indicators. On days 1, 6, 11, 16, 21, 26, and 31 after treatment, the cerebrospinal fluid (0.6 mL) of New Zealand rabbits was extracted by percutaneous cisternoma puncture. After centrifugation, the supernatant was used for the detection of inflammatory indicators, including interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and interleukin-1β (IL-1β).

2.5.3. Oxidative Stress Indicators. The cerebrospinal fluid supernatant dilution obtained in the previous step is used for the detection of oxidative stress index—cyclooxygenase (COX-2).

2.5.4. Cell Count. Routine blood leukocyte counts were performed on New Zealand rabbits in each group at 0, 6, and 12 h after operation. In addition, on the 10th, 20th, and 30th day after operation, three New Zealand rabbits in the operation group were killed by air injection, and the tissues of the operation area were paraffin-embedded for fibroblast count, and three fields of view were selected to take the average value.

2.6. Data Analysis. The experimental data was analyzed using SPSS 21.0 software. The measurement data is expressed as the mean ± standard deviation, and the counting data is expressed as the rate (%). $P < 0.05$ indicates that the data difference is statistically significant.

3. Results and Discussion

3.1. Characterization of Materials. The designed artificial dura mater (ePTFE/PLGA) was studied using a field emission scanning electron microscope at an accelerating voltage of 10.0 kV, and its surface morphology is shown in Figure 2. A clear network structure can be seen on the surface, and there are pores of different sizes interspersed in it.

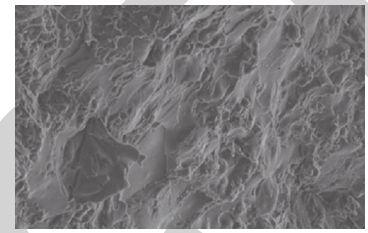

Figure 2: Characterization of new expanded polytetrafluoroethylene/polylactic acid-glycolic acid (ePTFE/PLGA) material under a scanning electron microscope (SEM).

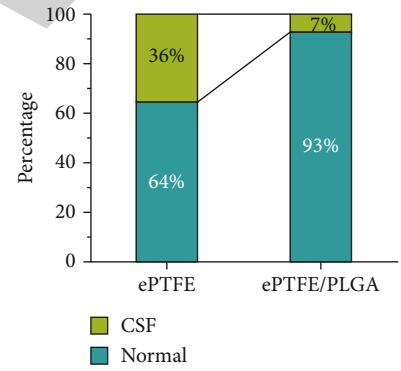

Figure 3: Cerebrospinal fluid leakage.

3.2. Cerebrospinal Fluid Leakage. The occurrence of cerebrospinal fluid leakage is shown in Figure 3. Among them, there were five cases of cerebrospinal fluid leakage in the ePTFE group, and the incidence of CSF was 36%, while only one case of the ePTFE/PLGA group had cerebrospinal fluid leakage, and the incidence of CSF was 7.0%. The experimental results show that ePTFE/PLGA is worthy of recognition in dural repair, and the combination with PLGA greatly improves the elasticity of ePTFE materials and makes up for the defects of ePTFE itself.

3.3. Inflammation Indicators. The ELISA method detects the changes in the concentration of inflammatory factors, and the results are shown in Figure 4. Within 1.0–31 days after surgery, the levels of IL-6 (Figure 4(a)), TNF-α (Figure 4(b)), and IL-1β (Figure 4(c)) in the cerebrospinal fluid of the model rabbits in the sham operation group fluctuated up and down with time, but there was no

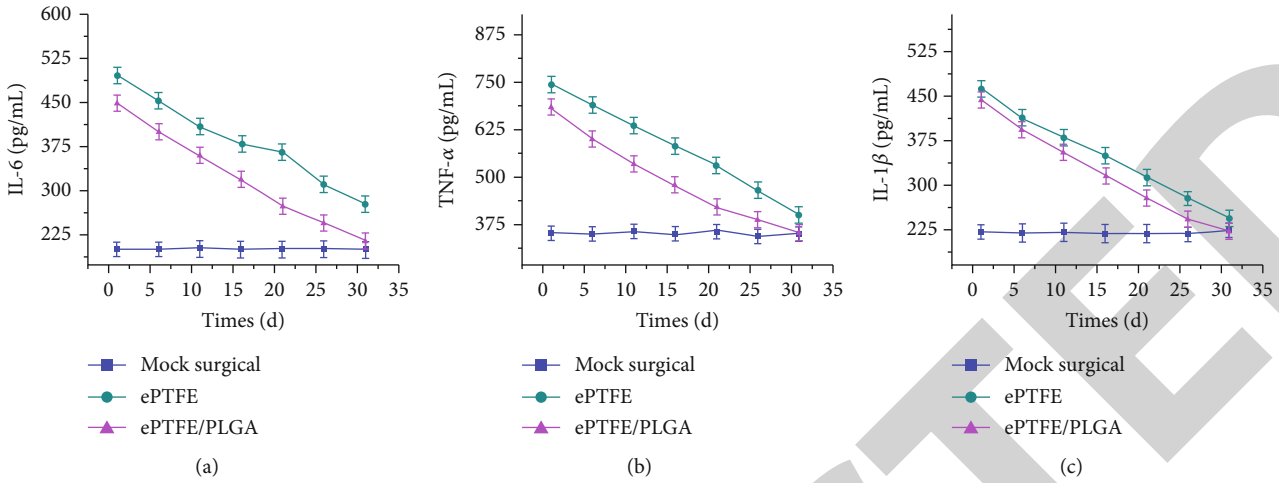

Figure 4: Inflammation indicators in the cerebrospinal fluid of New Zealand rabbits before and after treatment: (a) interleukin-6; (b) tumor necrosis factor-α; (c) interleukin-1β.

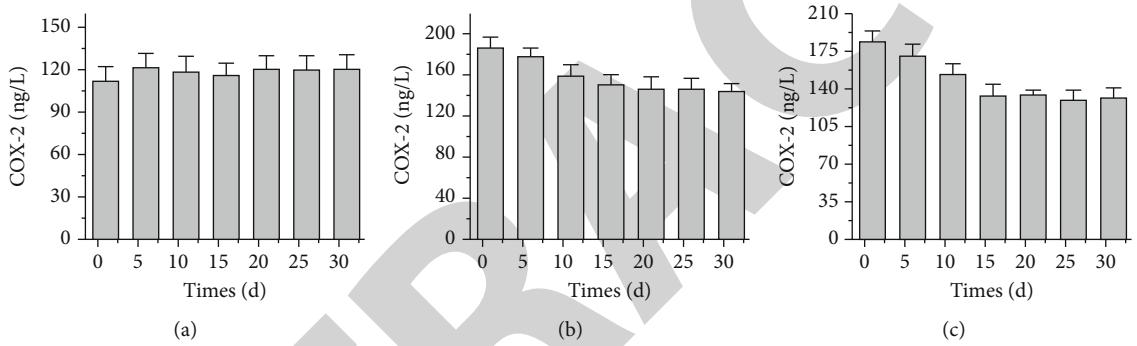

Figure 5: The changes of cyclooxygenase-2 levels in the cerebrospinal fluid of New Zealand rabbits in each group: (a) mock surgical group; (b) ePTFE group; (c) ePTFE/PLGA group.

significant change ($P > 0.05$). The levels of IL-6, TNF-α, and IL-1β in the ePTFE group and the ePTFE/PLGA group gradually decreased after the operation. Among them, the ePTFE/PLGA group declined faster than the ePTFE group, and the difference between the two groups was significant ($P < 0.05$). The experimental results show that the ePTFE/PLGA material has good biocompatibility, the foreign body reaction is small when the material is implanted in the body, and it can effectively avoid postoperative infection after dural repair.

3.4. Oxidative Stress Indicators. The oxidative stress index COX-2 of each group of New Zealand rabbits was recorded, and the results are shown in Figure 5. Among them, the COX-2 content in the sham operation group did not change significantly (Figure 5(a)). The COX-2 level in the ePTFE group decreased from 186.25 ± 10.43 ng/L to 144.58 ± 7.33 ng/L (Figure 5(b)), and the COX-2 level in the ePTFE/PLGA group decreased from 182.55 ± 10.33 ng/L to 130.77 ± 9.17 ng/L (Figure 5(c)). The results showed that the application of ePTFE/PLGA did not trigger a serious oxidative stress response, which is conducive to body recovery.

3.5. Cell Count. The relevant cell count data of the surgery group is shown in Figure 6. The change in the number of neutrophils is shown in Figure 6(a). In the first six days after surgery, neutrophils in the ePTFE and ePTFE/PLGA groups proliferated rapidly and dropped to a normal level on the 12th day. Among them, the peak neutrophil count in the ePTFE/PLGA group was 13.2×10^9/L, which was lower than that in the ePTFE group, indicating that the implantation of ePTFE/PLGA can effectively avoid the occurrence of postoperative bacterial infection. The count of fibroblasts is shown in Figure 6(b). Within 30 days after the operation, fibroblasts in the ePTFE group and the ePTFE/PLGA group proliferated in a large amount, which is conducive to the rapid repair of the dura mater. Among them, the ePTFE/PLGA group has a significantly higher multiplication rate than the ePTFE group.

4. Discussion

In neurosurgery, dural defects are very common. In order to maintain the integrity of the patient's dura mater, neurosurgeons have consistently applied dural occlusion to repair. In the centuries of attempts, medical practitioners have explored from autologous tissues to artificial synthetic materials, thus stopping the search for high-performance repair materials. At this stage, the application of artificial repair materials has

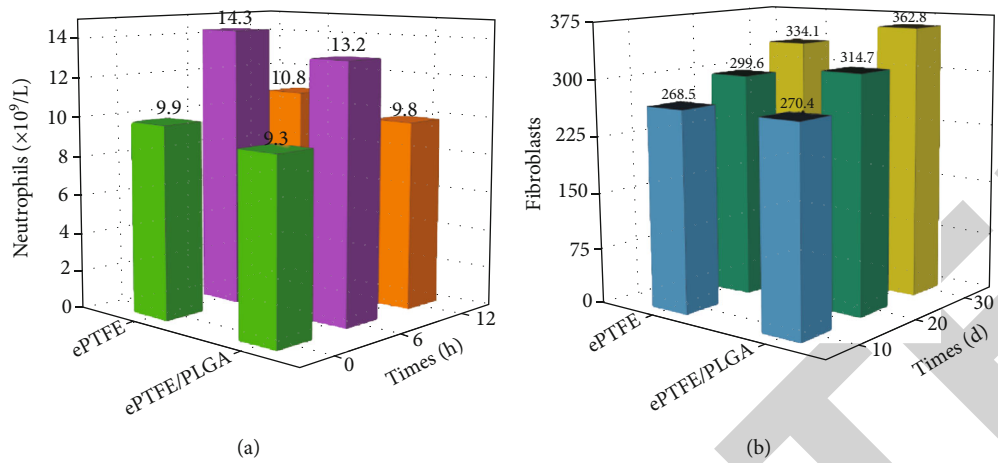

Figure 6: Cell counts: (a) neutrophils; (b) fibroblasts.

received support from many scholars. As a representative artificial dura mater, ePTFE has great potential in medical applications. However, there are reports in the literature of CSF adverse events of ePTFE in animal experiments, which limits the popularity of ePTFE in clinical practice.

In order to make up for the shortcomings of a single material, this study considered the design of a composite dura mater based on ePTFE. PLGA is widely used in the fields of pharmaceutical and medical engineering materials due to its excellent biocompatibility and degradability. In addition, the researchers also found that PLGA has good encapsulation and film-forming properties. In view of this, this work combined ePTFE and PLGA to synthesize a new type of ePTFE/PLGA material and conducted animal experiments on it. *In vivo* experiments have proved that the new composite dura mater material has great benefits in reducing the incidence of CSF. At the same time, ePTFE/PLGA can effectively inhibit postoperative inflammation and protect the health of the body. In addition, ePTFE/PLGA plays a positive role in promoting the proliferation of fibroblasts, and can significantly accelerate the repair process of the dura mater [28–30].

In summary, ePTFE/PLGA has outstanding performance in repairing dural defects in New Zealand rabbits, and it is an undeniable and extremely promising material. Through unremitting exploration, we believe that ePTFE/PLGA can be more perfectly applied to the clinic and benefit most patients.

5. Conclusion

In this work, we developed a new type of ePTFE/PLGA artificial dura mater to repair the dura mater of model rabbits. In vivo experiments have proved that the compound of PLGA can make up for the defects of a single ePTFE material and reduce the incidence of cerebrospinal fluid leakage. ePTFE/PLGA also showed good biocompatibility, and its application in the body did not trigger a strong foreign body reaction and oxidative stress reaction. Therefore, from the research status and lessons of dural defect and the basic analysis of the experimental species of new dural defect repair materials mentioned in this study, the application prospect of ePTFE/PLGA in the medical field in the future is immeasurable. This new material is expected to be more perfectly applied in clinic and benefit the majority of patients.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Ethical Approval

Research experiments conducted in this article with animals were approved by the Medical Ethics Committee of Binzhou Medical University Hospital following all guidelines, regulations, legal, and ethical standards as required for animals.

Conflicts of Interest

There is no potential conflict of interest in our paper, and all authors have seen the manuscript and approved to submit to your journal.

Acknowledgments

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References

[1] B. Mecheri, F. Paris, and H. Lübbert, "Histological investigations on the dura mater vascular system of mice," *Acta Histochemica*, vol. 120, no. 8, pp. 846–857, 2018.

[2] M. Protasoni, S. Sangiorgi, A. Cividini et al., "The collagenic architecture of human dura mater," *The Journal of Neurosurgery*, vol. 114, no. 6, pp. 1723–1730, 2011.

[3] H. M. B. Bolly, Y. Hermanto, A. Faried, M. Z. Arifin, T. L. Yembise, and F. F. Wirakusumah, "Protein-protein interaction analysis of contributing molecules in dura mater healing

process," *International Journal of ChemTech Research*, vol. 13, no. 3, pp. 73–82, 2020.

[4] S. K. He, J. H. Guo, Z. L. Wang et al., "Efficacy and safety of small intestinal submucosa in dural defect repair in a canine model," *Materials Science and Engineering: C*, vol. 73, pp. 267–274, 2017.

[5] C. A. Bohoun, T. Goto, H. Morisako, A. Nagahama, Y. Tanoue, and K. Ohata, "Skull base dural repair using autologous fat as a dural substitute: an efficient technique," *World Neurosurgery*, vol. 127, pp. e896–e900, 2019.

[6] J. H. Guo, S. K. He, Y. H. Tu et al., "A stable large animal model for dural defect repair with biomaterials and regenerative medicine," *Tissue Engineering Part C: Methods*, vol. 25, no. 6, pp. 315–323, 2019.

[7] Y. Ramot, S. Harnof, I. Klein et al., "Local tolerance and biodegradability of a novel artificial dura mater graft following implantation onto a dural defect in rabbits," *Toxicologic Pathology*, vol. 48, no. 6, pp. 738–746, 2020.

[8] M. Pukšec, D. Semenski, D. Ježek et al., "Biomechanical comparison of the temporalis muscle fascia, the fascia lata, and the dura mater," *Journal of Neurological Surgery Part B: Skull Base*, vol. 80, no. 1, pp. 023–030, 2019.

[9] R. Morales-Avalos, A. Soto-Domínguez, J. García-Juárez et al.Characterization and morphological comparison of human dura mater, temporalis fascia, and pericranium for the correct selection of an autograft in duraplasty procedures," *Surgical and Radiologic Anatomy*, vol. 39, no. 1, pp. 29–38, 2017.

[10] O. Oğretmenoğlu and G. Akyol, "The repair of cerebrospinal fluid rhinorrhea: comparison of histopathologic findings with cadaveric human temporal fascia, dura mater, and autologous fascia in a rabbit model," *Kulak Burun Bogaz Ihtisas Dergisi*, vol. 13, no. 1-2, pp. 1–8, 2004.

[11] T. Nakano, K. Yoshikawa, T. Kunieda et al., "Treatment for infection of artificial dura mater using free fascia lata," *Journal of Craniofacial Surgery*, vol. 25, no. 4, pp. 1252–1255, 2014.

[12] S. Yamada, T. Aiba, Y. Endo, M. Hara, T. Kitamoto, and J. Tateishi, "Creutzfeldt-Jakob disease transmitted by a cadaveric dura mater graft," *Neurosurgery*, vol. 34, no. 4, pp. 740–744, 1994.

[13] V. Vanaclocha and N. Saiz-Sapena, "Duraplasty with freeze-dried cadaveric dura versus occipital pericranium for Chiari type I malformation: comparative study," *Acta Neurochirurgica*, vol. 139, no. 2, pp. 112–119, 1997.

[14] Y. Nakamura, I. Oki, S. Tanihara et al., "A case-control study of Creutzfeldt-Jakob disease in Japan: transplantation of cadaveric dura mater was a risk factor," *Journal of Epidemiology*, vol. 10, no. 6, pp. 399–402, 2000.

[15] T. A. Barbolt, M. Odin, M. Léger, L. Kangas, J. Holste, and S. H. Liu, "Biocompatibility evaluation of dura mater substitutes in an animal model," *Neurological Research*, vol. 23, no. 8, pp. 813–820, 2001.

[16] F. R. Bella, P. Widiyanti, and Aminatun, "The effect of glycerol concentration on biocomposite bacterial cellulose-chitosan characterization as dura mater artificial," *Journal of Biomimetics, Biomaterials and Biomedical Engineering*, vol. 45, pp. 40–48, 2020.

[17] Y. Jing, X. Ma, C. Xu, H. L. Tian, and S. W. Chen, "Repair of dural defects with electrospun bacterial cellulose membranes in a rabbit experimental model," *Materials Science and Engineering: C*, vol. 117, pp. 111246–111246(27), 2020.

[18] E. Goldschmidt, M. Cacicedo, S. Kornfeld et al., "Construction andin vitrotesting of a cellulose dura mater graft," *Neurological Research*, vol. 38, no. 1, pp. 25–31, 2016.

[19] R. S. Angtika, P. Widiyanti, and Aminatun, "Bacterial cellulose-chitosan-glycerol biocomposite as artificial dura mater candidates for head trauma," *Journal of Biomimetics, Biomaterials and Biomedical Engineering*, vol. 36, pp. 7–16, 2018.

[20] H. T. Bui, A. R. W. Friederich, E. Li, D. A. Prawel, and S. P. James, "Hyaluronan enhancement of expanded polytetrafluoroethylene cardiovascular grafts," *Journal of Biomaterials Applications*, vol. 33, no. 1, pp. 52–63, 2018.

[21] Y. Yamamoto, M. Yamagishi, T. Miyazaki et al., "Modification of expanded polytetrafluoroethylene valved conduit using the thin-type leaflets," *The Journal of Thoracic and Cardiovascular Surgery*, vol. 156, no. 4, pp. 1629–1636.e3, 2018.

[22] D. F. Wang, Y. Y. Xu, Y. J. Lin et al., "Biologically functionalized expanded polytetrafluoroethylene blood vessel grafts," *Biomacromolecules*, vol. 21, no. 9, pp. 3807–3816, 2020.

[23] J. S. Gammie, P. Wilson, K. Bartus et al., "Transapical beating-heart mitral valve repair with an expanded polytetrafluoroethylene cordal implantation device," *Circulation*, vol. 134, no. 3, pp. 189–197, 2016.

[24] Z. Zhou, Q. Q. Yao, L. Li et al., "Antimicrobial activity of 3D-printed poly(ε-caprolactone) (PCL) composite scaffolds presenting vancomycin-loaded polylactic acid-glycolic acid (PLGA) microspheres," *Medical Science Monitor*, vol. 24, pp. 6934–6945, 2018.

[25] C. Martins, F. Sousa, F. Araújo, and B. Sarmento, "Functionalizing PLGA and PLGA derivatives for drug delivery and tissue regeneration applications," *Advanced Healthcare Materials*, vol. 7, no. 1, pp. 1701035(1)–1701035(24), 2018.

[26] B. T. Lu, X. K. Lv, and Y. Le, "Chitosan-modified PLGA nanoparticles for control-released drug delivery," *Polymers*, vol. 11, no. 2, pp. 304–304(14), 2019.

[27] A. M. Alkilany, S. R. Abulateefeh, and C. J. Murphy, "Facile functionalization of gold nanoparticles with PLGA polymer brushes and efficient encapsulation into PLGA nanoparticles: toward spatially precise bioimaging of polymeric nanoparticles," *Particle & Particle Systems Characterization*, vol. 36, no. 2, pp. 1800414(1)–1800414(8), 2018.

[28] E. Goldschmidt, S. Hem, P. Ajler et al., "A new model for dura mater healing: human dural fibroblast culture," *Neurological Research*, vol. 35, no. 3, pp. 300–307, 2013.

[29] A. Kinaci, W. Bergmann, R. L. Bleys, A. Van der Zwan, and T. P. Van Doormaal, "Histologic comparison of the dura mater among species," *Comparative Medicine*, vol. 70, no. 2, pp. 170–175, 2020.

[30] Q. Li, F. H. Zhang, H. M. Wang, and T. Pan, "Preparation and characterization of a novel acellular swim bladder as dura mater substitute," *Neurological Research*, vol. 41, no. 3, pp. 242–249, 2019.