

Use of Electrostatic Spinning Synthetic Dura Substitute for Repair of Spinal Dural Mater: Case Reports

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Abstract

We reported the earliest cases involving electrostatic spinning synthetic dura substitutes for repairing defects in the spinal dura mater. From June to September 2017, seven patients were treated with electrostatic spinning synthetic dura substitute. The laminotomy was performed for all the patients, and the cancers were resected, then the electrostatic spinning synthetic dura substitute made of polylactic acid ReDura™. All of the patients had no complications and might be the ideal promising alternative for repairing the spinal dura mater.

Keywords

Spinal Dura Mater, Electrostatic Spinning, Substitute

1. Introduction

Spinal dura mater tears are a common issue in surgical procedures, especially in intradural tumor resection [1] [2]. Spinal dura mater tears can result in some complications, such as cerebrospinal fluid leak, headache, infection, and fever [3]. Primary dural closure with sutures is the preferred method for spinal duraplasty, whenever possible, to minimize the risk of persistent cerebrospinal fluid leak, optimizing recovery and outcome. When direct repair with suture is not possible, the resort to indirect repair by fat or muscle patches, which lengthen the surgery length and secondary injury for patient because of the fat or muscle access, and a

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lot of implant grafts are approved to repair the defect cranial dura mater, but implant grafts approved to repair the spinal dura mater are not much, which perhaps it's the spinal dura mater differs from the cranial dura mater [4].

Nowadays, electrostatic spinning fibers have been used for various biomedical applications, including dural regeneration, due to their interesting properties, such as porosity, superior mechanical properties, and most importantly, similarity with the extracellular matrix (ECM) [5].

Here, we retrospectively reviewed the earliest cases involving the use of electrostatic spinning synthetic dura substitute for repairing defects in the spinal dura mater 2017.

2. Cases Report

From June to September 2017, seven patients were treated in the Neurosurgery Department, Peking University Third Hospital, China. The pre-operative diagnosis for all the cases was established by magnetic resonance imaging (MRI) and computed tomography (CT), and the lesions were located in the thoracolumbar regions and were symptomatic as shown in **Table 1** and **Table 2**. The most common symptom, present in six cases, was increasing progressive paralysis and walking difficulty. One case was back pain and the patient couldn't bend her back, and the symptom was progressive. (**Table 1**)

The laminotomy was performed for all the patients and the cancers were resected, then the electrostatic spinning synthetic dura substitute made of polylactic acid ReDuraTM, which has been approved by CFDA before 2017, was onlay on the

Table 1. Pre-operative information.

Patient No.	Sex	Years	Clinical history	Pre-operative assessment
1	F	65	There was numbness in both lower extremities with no infiltration more than a year ago, and then weakness in both lower extremities with walking difficulty when symptoms aggravated six months ago.	Intraspinal space-occupying lesions
2	F	69	The patient developed limb weakness accompanied by numbness in both lower limbs six months ago, accompanied by paraesthesia with holes and cleats. The symptoms aggravated in the past 10 days.	Intraspinal space-occupying lesions
3	F	20	Back pain 3 years ago accidentally and unable to bend down. Back pain aggravated one year ago.	Intraspinal space-occupying lesions
4	F	32	The patient presented with double pseudoweakness and numbness before the previous year, and the proximal visceral symptoms aggravated in a month.	Intraspinal space-occupying lesions
5	F	61	After posterior cervical surgery, the right lower thigh was numb and immobilized, and walking was difficult.	Intraspinal space-occupying lesions
6	M	28	Intermittent pain in the right lower leg for half a month.	Intraspinal space-occupying lesions
7	F	30	The left-back and lower leg pain accidentally, and it can be relieved after rest.	Intraspinal space-occupying lesions

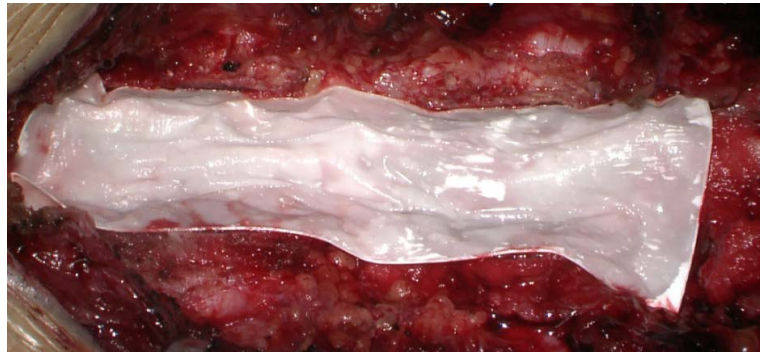


Figure 2. ReDura™ covered over the defect with onlay.



Figure 3. T2-weighted magnetic imaging(T2WI) of thoracolumbar (post-operative).

like CSF leak, cerebral contusion, hemorrhage, or wound infection, as well as pseudo meningocele were observed in the follow-up month.

4. Discussion

The dura mater is the outermost meningeal membrane enclosing the brain and spinal cord. The cerebrospinal fluid steadily flows under the dura mater. When the dural defect occurs, the leakage of cerebrospinal fluid will result in several complications. In this study, seven cases of spinal duraplasty were repaired with the electrostatic spinning fibers synthetic dura substitute ReDura™ did not find the cerebrospinal fluid leakage and the other related complications, which showed that the electrostatic spinning fibers synthetic dura substitute can effectively repair the defect spinal dura mater.

A. L. Miguel Angel Reina *et al.* study showed that at the spinal level, the dura

mater is composed of collagen fibers and about 80 concentric dural laminas measuring approximately 250 - 400 μm . Each dural lamina has a thickness of 5 μm and is formed by thinner laminas. These collagen fibers are oriented in various directions and form each dural lamina, and these fibers measure 2 μm in diameter and have a rough surface [6].

ReDura™ is manufactured by electrostatic spinning, which is composed of a lot of fibers in microstructure, and Kunxue Deng reported [7] that each fiber's average diameter of ReDura™ is about 1 - 2 μm , with the structure and fiber diameter similar to the human spinal dura mater microstructure [6]. Besides, Bernhard Schick reported [8] cellular migration from the dura borders at the site of the defect during the wound healing process. Thus, the fiber graft is the ideal biomimetic dural cell matrix for cellular migration and could help the defective spine dura mater repair.

Except for the above biomimetic microstructure of ReDura™, its mechanical properties are also similar to those of the spinal dura mater. Runza *et al.* [9] reported Young's moduli of 4 - 6 MPa, and Sacha Cavalier *et al.* reported similar results [3]. Kunxue Deng reported [7] that the tense strength of ReDura™ 4.80 - 5.49 MPa, which is similar to that of the human spinal dura mater.

Therefore, the electrostatic spinning technology manufactured by the substitute can provide both a similar cell-matrix and mechanical properties, which make the substitute similar to native spine dura mater as far as possible.

However, these cases only have a follow-up duration of 1 - 3.5 months, but for spinal dural repair, long-term follow-up data will be more helpful in tracking the clinical performance of the material, and potential long-term complications are usually paid attention in the dura substitute.

5. Conclusions

We retrospectively reviewed the earliest cases involving electrostatic spinning synthetic dura substitute for repairing defects in the spinal dura mater in 2017, and no complication was found in these cases after surgery. Because of the technical characteristics of electrostatic spinning, electrostatic spinning synthetic dura substitute can provide cell-trix and mechanical properties similar to native spine dura mater.

Thus, the electrostatic spinning synthetic dura substitute might be the ideal promising alternative for repairing the spinal dura mater.

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Authors' Contributions

Limin Lin, Kunxue Deng and Hongji Yang performed and analyzed the data and

drafted the manuscript. Zhenyu Wang and Chenxiao Dong collected the data and performed the data analysis. Bin Liu conceived of and designed the study and revised the paper. All authors reviewed the results and approved the final version of the manuscript.

Statement

These patients or family representatives in these cases were contacted by telephone to obtain verbal informed consent about the case reports to be published.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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