

# Use of 'stacked' dermal template: Biodegradable temporising matrix to close a large myelomeningocele defect in a newborn

Scars, Burns & Healing  
Volume 10: 1–8  
DOI: 10.1177/20595131241270220  
Article reuse guidelines:  
sagepub.com/journals-permissions  
© The Author(s) 2024  
journals.sagepub.com/home/sbh



Saiidy Hasham<sup>1</sup> , Ciaran O'Boyle<sup>1,2</sup> and Skaria Alexander<sup>1,2</sup>

## Abstract

**Background:** Myelomeningocele is a severe and complex congenital malformation of the central nervous system. Failure of neural tube closure at around four weeks of gestation results in an open communication between the neural placode and the external environment with varied functional impairment. Surgery is usually required.

**Objectives:** The primary goals of surgical management are to preserve neural function and minimise infection. Reconstruction is dependent upon the site and size of the defect as well as the quality of the surrounding soft tissues. Surgeons may employ a range of reconstructive techniques in order to achieve closure. Skin substitutes, also known as dermal regeneration templates, have also been utilised.

**Discussion:** In our unit, we use NovoSorb Biodegradable Temporising Matrix to reconstruct full-thickness skin and soft tissue defects. It is a synthetic, biodegradable, dermal regeneration template, composed of polyurethane foam bonded to a transparent sealing membrane and typically requires a two stage reconstruction. Integration and vascularisation take approximately three weeks. After this time, the recipient wound bed is suitable for split thickness skin grafting. A further benefit of dermal regeneration templates is the possibility of 'stacking' layers, which serves to increase the thickness of the final construct and to minimise overall contour defects. The authors present the case of a one-day-old full-term neonate with a large lumbosacral myelomeningocele that was successfully managed with staged, stacked NovoSorb Biodegradable Temporising Matrix and split thickness skin grafting. The authors believe this is the first case in which a 'stacked' dermal regeneration templates has been used to achieve healing of a primary myelomeningocele defect.

## Keywords

Myelomeningocele, Novosorb Biodegradable Temporising Matrix, spina bifida, neural tube defect, reconstruction, dermal regeneration template, skin graft

<sup>1</sup>Plastic Surgery & Burns Department, Nottingham University Hospitals NHS Trust, Nottingham, UK

<sup>2</sup>University of Nottingham Medical School, Nottingham, UK

## Corresponding author:

Saiidy Hasham, Queens Medical Centre, Nottingham University Hospitals NHS Trust, Derby Road, Nottingham, NG7 2UH, UK.  
Email: saiidyhasham@hotmail.com



## Lay Summary

**Background:** NovoSorb Biodegradable Temporising Matrix (BTM) is a dermal regeneration template (DRT) and is used to reconstruct wounds following full-thickness skin and soft tissue loss resulting from burn injury, trauma, infection or surgery. It is composed of 2-millimetre thick, synthetic, biodegradable polyurethane foam bonded to a transparent (non-biodegradable) sealing membrane. Like all DRTs, it acts as a scaffold for cellular integration and vascularisation to eventually form a 'neo-dermis'. This is usually apparent from around three weeks. A second stage procedure can then be performed, with removal of the outer sealing membrane and split thickness skin grafting of the vascularised layer.

**Objectives:** Myelomeningocele is a severe and complex congenital malformation of the central nervous system and forms the group of anomalies commonly referred to as neural tube defects (NTDs). Neural tube closure usually occurs at around four weeks of gestation and failure to do so, results in an open communication between the neural placode and the external environment. The degree of functional impairment varies but can include: lower limb paralysis; sensory loss; bladder and bowel dysfunction. In order to preserve neural function and minimise the risk of infection, surgery is usually required to close the defect. Reconstruction is varied and is dependent upon the site and size of the defect as well as the quality of the surrounding soft tissues. The use of local flaps has the potential complication of skin necrosis. Muscle based flaps may be debilitating and limit future functionality and worsen postural development. We were presented with a one-day-old neonate with a large lumbosacral myelomeningocele. A DRT (NovoSorb BTM) was selected as the primary reconstruction. Firstly, selection provided relatively low risk, with minimal morbidity and preserved the full complement of flap based reconstructive options for a later stage should instrumentation be required. Secondly, NovoSorb BTM conferred a robust seal over the dural repair with no demonstrable cerebrospinal fluid leak. Thirdly, the ability to add layers ('stack') of NovoSorb BTM in stages, once integration and vascularisation of the previous layer is complete, allows reconstruction of deeper contour defects.

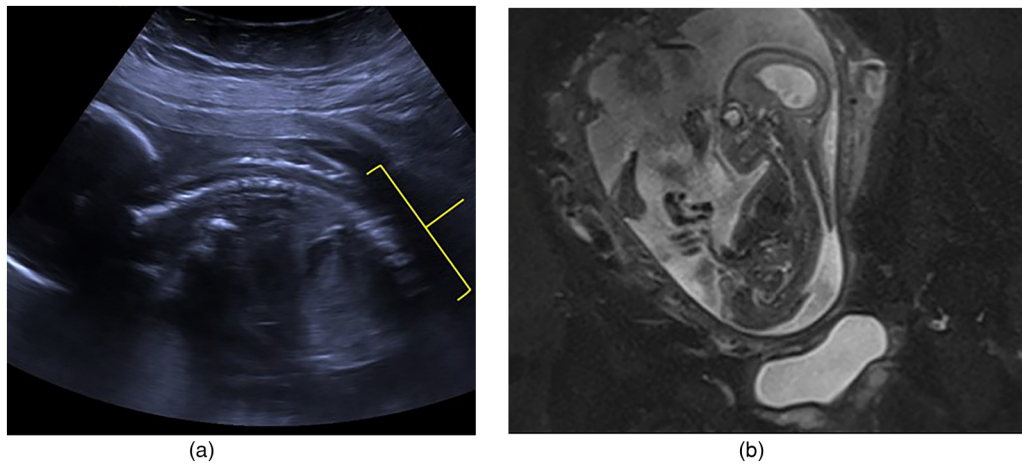
**Discussion:** We have illustrated the successful use of NovoSorb BTM as a DRT to achieve closure of a large lumbosacral myelomeningocele without complication and with longstanding stability. We believe this technique provides reconstructive teams with an alternative option that is effective, safe and reproducible and which spares local tissues for future elective reconstructive procedures, should they be required.

## Background

Myelomeningocele is a severe and complex congenital malformation of the central nervous system and forms the group of anomalies commonly referred to as neural tube defects (NTDs). Part of the *spina bifida* spectrum, it occurs due to failure of neural tube closure at around four weeks of gestation and results in an open communication between the neural placode and the external environment.<sup>1</sup> The degree of functional impairment varies and this is dependent on the vertebral level affected as well as the extent of the lesion but usually results in: lower limb paralysis; sensory loss; bladder dysfunction; bowel dysfunction; and cognitive dysfunction.<sup>2</sup> The prevalence of NTDs varies globally. Different rates have been documented based on ethnic and geographical characteristics, as well as being influenced by the availability of prenatal detection. An average of

1 in 1000 live births are affected worldwide.<sup>3</sup> The aetiology and pathogenesis of spina bifida is multi-factorial with genetics, nutrition and environmental factors all playing a role.<sup>4</sup>

The main objectives of surgical management are to preserve neural function and to minimise risk of infection. Reconstruction is varied and is dependent upon the site and size of the defect as well as the quality of the surrounding soft tissues.<sup>5</sup> Robust dural coverage of neural elements within the spinal canal and stable soft tissue coverage is integral in preventing cerebrospinal fluid (CSF) leakage and wound dehiscence and should be undertaken as early as possible following birth.<sup>6</sup> Numerous methods of reconstruction have been described ranging from direct closure (with or without skin undermining and relaxing incisions); skin grafting; local fasciocutaneous flaps (random or perforator-based); myofascial turnover flaps (with or without paraspinous muscle flaps) as well as regional



**Figure 1.** (a) Ultrasound scan performed at 21 weeks gestation. Defect demonstrated by marker. (b) Fetal MRI scan confirming myelomeningocele defect.

muscle-based flaps, e.g., *Latissimus dorsi*, *Gluteus maximus*.<sup>5–16</sup>

Skin substitutes, also known as dermal regeneration templates (DRT), have been employed in combination with flaps both *in utero* and postnatally with good effect.<sup>8,17,18</sup> The authors have used NovoSorb Biodegradable Temporising Matrix (BTM; PolyNovo Ltd, Port Melbourne, Victoria, Australia) to reconstruct complex wounds. This has been utilised in full-thickness skin and soft tissue defects resulting from burn injury, trauma, infection or surgery.<sup>19–23</sup> It is a 2-millimetre thick, synthetic, biodegradable DRT and is composed of polyurethane foam bonded to a transparent (non-biodegradable) sealing membrane and typically requires a two-stage reconstruction. Integration and vascularisation lead to the formation of a ‘neo-dermis’ and this is usually apparent from approximately three weeks. At this time, the sealing membrane starts to delaminate by separating from the underlying integrated foam to reveal a vascularised wound bed. This is demonstrated by a colour change from white to a pinkish red with blanching observed on palpation. A second stage procedure can then be performed, with removal of the outer sealing membrane and split thickness skin grafting of the ‘neo-dermis’ layer.

Empirical evidence suggests that NovoSorb BTM may confer relative resistance to infection and to skin contracture and improve post-operative skin pliability.<sup>19,24,25</sup> A further benefit of DRTs is the possibility of ‘stacking’, with an additional layer added, once vascularisation of the outermost DRT layer is complete. This serves to increase the thickness of the final construct and to minimise overall contour defects.

The authors present the case of a one-day-old full-term neonate with a large lumbosacral myelomeningocele that was successfully managed with staged, stacked NovoSorb BTM and split thickness skin grafting to achieve a robust and durable reconstruction. The authors believe this is the first case in which a ‘stacked’ DRT has been used to achieve healing of a primary meningocele defect. In addition, this case describes the youngest patient to be reconstructed using multiple layers of a DRT.

### Case study

A male newborn was delivered under the combined care of obstetricians and neurosurgeons, following elective Caesarean section, at 38 weeks gestation. Antenatal diagnosis of *spina bifida* had been made on anomaly ultrasound scan performed at 21 weeks (Figure 1(a)) and confirmed by fetal MRI scan (Figure 1(b)). This showed a large mid-thoracic myelomeningocele as well as kyphoscoliosis, ventriculomegaly and Chiari malformation (Type II). Following delivery and combined clinical assessment, a surgical plan for repair and reconstruction was made by plastic surgeons and neurosurgeons.

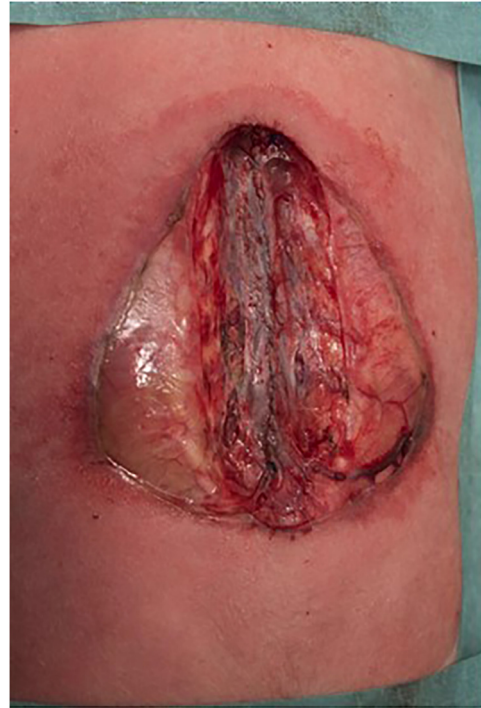
At day one post-partum, dural repair of the myelomeningocele was performed. The defect was measured at 8 × 7 cm (Figure 2). The neural placode was circumferentially dissected and any non-functioning neural filaments were removed. The placode was subsequently inverted and closed using 4/0 polypropylene sutures to reconstruct a neural tube (Figure 3). With no apparent dural plane evident, the adjacent paraspinal



**Figure 2.** Primary lumbar myelomeningocele at 1-day post-partum. Defect measured 8 × 7 cm.

muscular fascia was incised laterally, elevated and brought medially to envelop the neural tube and closed with further 4/0 polypropylene sutures. Due to tethering of the surrounding skin and the size of the defect, safe reconstruction using local soft tissue options was not deemed possible. As a result, a DRT (NovoSorb BTM) was selected. A single sheet (10 × 10 cm) of NovoSorb BTM was cut to the size and shape of the defect, ARTISS (Baxter Healthcare, Newbury, UK) fibrin sealant spray was applied to the wound bed prior to application to aid adherence and the DRT was affixed using 4/0 polypropylene sutures (Figure 4). A non-adherent silicone interface dressing (NA Ultra, Systagenix, Gargrave, UK) was applied over the NovoSorb BTM and the whole wound was sealed within a negative pressure wound therapy (NPWT) dressing (V.A.C., 3M, St Paul, Minnesota, USA). This was set at a continuous pressure of -25mmHg to provide splintage of the DRT and to minimise any loss of CSF. The NPWT attachment to its non-collapsible tubing was sited on the anterior abdomen, in order to avoid compression effect upon the skin of the back.

Over the next 12 days the patient returned to theatre twice for change of NPWT dressing and



**Figure 3.** Tubularised dural repair.

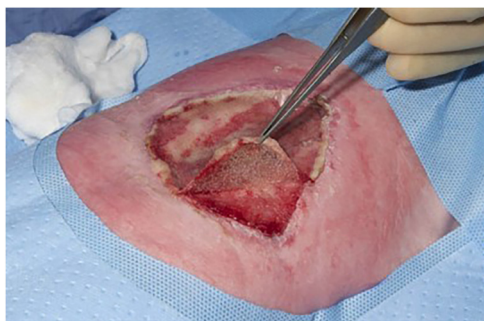


**Figure 4.** First DRT layer at primary procedure, prior to application of NPWT dressing.

inspection of the NovoSorb BTM. By day 19, the outer sealing membrane of the NovoSorb BTM had delaminated and the underlying foam was



**Figure 5.** Three weeks post-partum. DRT is integrated, with complete vascularisation (red colour) and delamination of bonded polyurethane top layer (pale areas).



**Figure 6.** Removal of polyurethane top layer, revealing vascularised 'neo-dermis'.

completely vascularised (Figures 5 and 6). A further sheet of NovoSorb BTM was applied at this point and the above process was repeated (Figure 7). On day 23, an ultrasound-guided right parietal ventriculoperitoneal shunt (VPS) was placed, to relieve hydrocephalus. A further change of NWPT dressing was performed on day 26 and split skin grafting of the second DRT layer was carried out on day 40 (Figures 8 and 9). A hand-fenestrated 8/1000-inch-thick skin graft was harvested from the outer aspect of the



**Figure 7.** Second 'stacked' DRT layer, prior to application of NPWT dressing.



**Figure 8.** Full integration and vascularisation of second DRT layer.

right thigh and affixed with absorbable 4/0 sutures (Vicryl Rapide, Ethicon, Cincinnati, USA) (Figure 10). NWPT was used again to protect and splint the graft. A graft review seven days later demonstrated full take. No wound complications were encountered thereafter.

A review at one year post-operatively, demonstrated the patient to be in good health with no skin or soft tissue problems experienced at the reconstruction or skin graft donor site. The skin



**Figure 9.** Second layer of DRT demonstrating a vascularised wound bed with punctate bleeding.



**Figure 10.** Third reconstructive procedure: split thickness skin graft secured over second DRT layer.

over the reconstruction was soft, pliable and maintained a good contour with the surrounding tissues (Figure 11). The scar around the periphery of the reconstructed area was slightly hypertrophic and was treated with a scar therapy program and continues to be under regular review. At the time of writing, no further reconstruction was required.



**Figure 11.** Appearance 1-year post-partum. Stable, robust soft tissue coverage. Peripheral scar is slightly hypertrophic.

## Discussion

The rationale for early surgical intervention for myelomeningocele is to preserve neural function and reduce the risk of infection. If at all possible, this should be performed within the first few days of life. Early closure has been shown to be a significant determinant in enhancing neurosurgical outcome.<sup>26</sup> The principles of reconstruction are dependent upon the size and site of the defect as well as the state of the surrounding tissues. It is important to minimise tension across the line of closure and to provide stable soft tissue coverage of the dural repair and prevent CSF leak. Numerous techniques for myelomeningocele closure have been described. Collectively, these illustrate the spectrum of soft tissue reconstruction, the variety of surgical experience and degree of local resource availability, which fall outside the remit of this article.

Most lumbosacral myelomeningocele defects can be closed directly.<sup>6,9</sup> Larger defects will pose reconstructive challenges. Local fasciocutaneous flaps are still advocated and have a role in the moderate to large myelomeningocele defects.<sup>5,9-12</sup> However, owing to the potential need for extensive skin undermining to achieve primary closure, concerns still remain with regards to progressive skin necrosis and flap failure following surgery. Large musculocutaneous flaps may provide durable soft tissue coverage by reinforcing the dural repair, reduce dead space and provide a robust barrier

between the spinal cord and skin. However, donor site morbidity can be high.<sup>14,16</sup> Harvesting of muscle flaps comprising *Latissimus dorsi* or *Gluteus maximus*, in an already neurologically compromised child, has the potential to limit future functionality and worsen postural development.<sup>13</sup> In addition, operative scars on the posterior trunk may complicate planning for any subsequent reconstruction.

A number of factors influenced the decision to select NovoSorb BTM as the primary reconstruction in the case presented. Firstly, a procedure involving DRT placement is relatively low risk, with minimal morbidity (e.g., blood loss) and preserves the full complement of flap based reconstructive options for a later stage if required. This in effect ‘buys time and tissue’, allows for growth and expansion of the soft tissues, which could then permit future instrumentation and reconstruction. The skin over the DRT repair was of good quality and pliability one year following surgery, with the area being treated as ‘normal skin’ with no additional safety precautions required. Secondly, NovoSorb BTM conferred a robust seal over the dural repair. This was evident with no demonstrable CSF leak or any sub-DRT fluid collection during the hospital admission. Thirdly, the ability to add layers (‘stack’) of NovoSorb BTM in stages, once integration and vascularisation of the previous layer is complete, allows reconstruction of deeper contour defects with a further 2 millimetres being added with each layer. The authors acknowledge that in order to reach completion, reconstruction requires several procedures under general anaesthetic, which in turn may not be feasible or practicable for all centres providing reconstruction of myelomeningocele defects.

The use of a NWPT dressing in this case was discussed prior to surgery with the neurosurgical team. Negative pressure would have potential to worsen the effects on any CSF leak. However, at operation, the dural repair along with its fascial envelope was confirmed to be complete and sufficiently ‘water-tight’ to allow the placement of a NWPT device. In addition, the DRT provides an interposed layer, protecting the dura from any direct effects of negative pressure. The benefits of a NWPT dressing for DRT care include: splinting; drainage; wound hygiene; and vascularisation.<sup>27</sup>

The development of fetal *spina bifida* surgery, presents the possibility of improved neurological outcomes compared to postnatal surgery, when performed before 26 weeks gestation.<sup>28</sup> Currently in the United Kingdom, this technique is subject

to specific inclusion criteria and is limited to a small number of specialist institutions. In most centres, postnatal repair of myelomeningocele remains the only option.

The authors describe successful use of the NovoSorb BTM as a DRT to achieve closure of a large lumbosacral myelomeningocele without complication and with longstanding stability. We believe this technique provides reconstructive teams with an alternative option that is effective, safe, reproducible and which spares local tissues for future elective reconstructive procedures, should they be required.


### Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: PolyNovo Limited have funded part of the publication fee.

### ORCID iD

Saiidy Hasham  <https://orcid.org/0000-0002-0506-448X>

### References

1. Dias M and Lane J. Myelomeningocele closure: An embryological perspective. *Cureus* 2020; 12: e9682.
2. Phillips LA, Burton JM and Evans SH. Spina bifida management. *Curr Probl Pediatr Adolesc Health Care* 2017; 47: 173–177.
3. Mitchell LE. Epidemiology of neural tube defects. *Am J Med Genet C Semin Med Genet* 2005; 135C: 88–94.
4. Peake JN, Knowles RL, Shawe J, et al. Maternal ethnicity and the prevalence of British pregnancies affected by neural tube defects. *Birth Defects Res* 2021; 113: 968–980.
5. Sharma MK, Kumar N, Jha MK, et al. Experience with various reconstructive techniques for myelomeningocele defect closure in India. *JPRAS Open* 2019; 21: 75–85.
6. Gaskill SJ. Primary closure of open myelomeningocele. *Neurosurg Focus* 2004; 16: 1–4.
7. Luce EA, Stigers SW, Vandenbrink KD, et al. Split thickness skin grafting of the myelomeningocele defect: a subset at risk for late ulceration. *Plast Reconstr Surg* 1991; 87: 116–121.
8. Yap P, Mat Saad AZ, Wan Sulaiman WA, et al. Closure of a large lumbosacral defect using a combined method of bilateral bipedicle flap with lateral releasing incision and Integra® dermal regeneration template. *Pediatr Traumatol Orthop Reconstructive Surg* 2021; 9: 345–351.
9. Shim J-H, Hwang N-H, Yoon E-S, et al. Closure of myelomeningocele defects using a Limberg flap or direct repair. *Arch Plast Surg* 2016; 43: 26–31.
10. Lobo CJ and Nayak M. V-Y plasty or primary repair closure of myelomeningocele: our experience. *J Pediatr Neurosci* 2018; 13: 398–403.
11. El-Sabbagh AH and Zidan AA. Closure of large myelomeningocele by lumbar artery perforator flaps. *J Reconstr Microsurg* 2011; 27: 287–294.

12. Duffy FJ Jr, Weprin BE and Swift DM. A new approach to closure of large lumbosacral myelomeningoceles: The superior gluteal artery perforator flap. *Plast Reconstr Surg* 2004; 114: 1864–1868.
13. Patel KB, Taghinia AH, Proctor MR, et al. Extra dural myelomeningocele reconstruction using local turnover fascial flaps and midline linear skin closure. *JPRAS* 2012; 65: 1569–1572.
14. Zakaria Y and Hasan EA. Reversed turnover latissimus dorsi muscle flap for closure of large myelomeningocele defects. *J Plast Reconstr Aesthet Surg* 2010; 63: 1513–1518.
15. El-Khatib HA. Large thoracolumbar meningomyelocele defects: incidence and clinical experiences with different modalities of latissimus dorsi musculocutaneous flap. *Br J Plast Surg* 2004; 57: 411–417.
16. Ramirez OM, Ramasastry SS, Granick MS, et al. A new surgical approach to closure of large lumbosacral meningomyelocele defects. *Plast Reconstr Surg* 1987; 80: 799–809.
17. North WD, Khoury L, Spears C, et al. Use of dermal regeneration template to close a giant myelomeningocele in a newborn. *J Neurosurg Pediatr* 2016; 18: 635–637.
18. Meuli M, Meuli-Simmen C, Flake AW, et al. Premiere use of Integra™ artificial skin to close an extensive fetal skin defect during open in utero repair of myelomeningocele. *Pediatr Surg Int* 2013; 29: 1321–1326.
19. Solanki NS, York B, Gao Y, et al. A consecutive case series of defects reconstructed using Novosorb® Biodegradable Temporising Matrix: Initial experience and early results. *J Plast Reconstr Aesthet Surg* 2020; 73: 1845–1853.
20. Damkat-Thomas L, Greenwood JE and Wagstaff MJD. A synthetic Biodegradable Temporising Matrix in degloving lower extremity trauma reconstruction: A case report. *Plast Reconstr Surg Global Open* 2019; 7: e2110.
21. Wagstaff MJD, Salna I, Caplash Y, et al. Use of a biodegradable synthetic dermal matrix in the reconstruction of defects after serial debridement for necrotising fasciitis: A case series. *Burns Open* 2018; 3: 1–30.
22. Wagstaff MJD, Schmitt BJ, Caplash Y, et al. Free flap donor site reconstruction. A prospective case series using an optimized polyurethane temporizing matrix. *Eplasty* 2015; 15: 231–248.
23. Greenwood JE, Schmitt BJ and Wagstaff MJD. Experience with a synthetic bilayer biodegradable temporising matrix in significant burn injury. *Burns Open* 2018; 2: 17–34.
24. Greenwood JE and Dearman BL. Split skin graft application over integrating, biodegradable temporising polymer matrix: Immediate and delayed. *J Burn Care Res* 2012; 33: 7–19.
25. Greenwood JE. A paradigm shift in practice – the benefits of early active wound temporisation rather than early skin grafting after burn eschar excision. *Anaesth Intensive Care* 2020; 48: 93–100.
26. Siahaan AMP, Susanto M, Lumbanraja SN, et al. Long-term neurological cognitive, behavioral, functional and quality of life outcomes after fetal myelomeningocele closure: a systematic review. *Clin Exp Pediatr* 2023; 66: 38–45.
27. Diehm YF, Fischer S, Gazyakan E, et al. Negative pressure wound therapy as an accelerator and stabiliser for incorporation of artificial dermal skin substitutes – A retrospective, non-blinded and non-randomised comparative study. *J Plast Reconstr Aesthet Surg* 2021; 74: 357–363.
28. Adzick NS, Thom EA, Spong CY, et al. A randomized trial of prenatal versus postnatal repair of myelomeningocele. *N Eng J Med* 2011; 364: 993–1004.