ORIGINAL ARTICLE

Free omental patch as the promising future for incisional hernia surgery: an experimental study in rat model

Imam Sofii, MD[4], Irianiwati Widodo, PhD[1], Gunadi, PhD[2], Adeodatus Y Handaya, MD[3]

[1]Department of Anatomical Pathology, Sardjito Hospital, Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, Yogyakarta, Indonesia, [2]Pediatric Surgery Division, Department of Surgery, Sardjto Hospital, Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, Yogyakarta, Indonesia, [3]Digestive Surgery Division, Department of Surgery, Sardjito Hospital, Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, Yogyakarta, Indonesia, [4]Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, Yogyakarta, Indonesia

ABSTRACT

Introduction: Incisional hernia is the common complication of abdominal surgery with serious morbidity. The use of Composite mesh (CM) is the current gold standard, which is superior to Polypropylene mesh (PPM) for closing the defect, due to its minimal intraabdominal adhesion.

In this study, we were using the novel combination of free omental patch (FOP) and PPM compared to CM for defect closure surgery in incisional hernia using rat models. We compared the gene expression of VEGF, COL3A1, COL1A1, COL1A2, and ratio of COL1A1/COL3A1 as the representative of wound healing process from all treatment options.

Materials and Methods: Eighteen wistar rats were made into incisional hernia models and divided into three groups of FOP, FOP-PPM, and CM at the 14th day. After each group underwent hernia repair, abdominal wall samples were taken to examine the expression of qPCR VEGF, COL3A1, COL1A1, and COL1A2 at the 21st day.

Results: There were no significant different in the gene expression of VEGF, COL3A1, COL1A1, COL1A2 and COL1A1/COL3A1 ratio between FOP, FOP-PPM and CM group (p-value >0.05). In addition, non-significant result also found at the comparative analysis between FOP-PPM and MC groups.

Conclusions: FOP can give the similar result as CM for defect closure surgery in incisional hernia, either when combined with PPM or as a single option. However, further clinical study is needed to support this animal study.

KEYWORDS:
Incisional hernia, collagen type 1 alpha-subunit, surgical mesh, Polypropylene mesh, composite mesh, free omental patch, ascular Endothelial Growth Factor A, Wistar rat

INTRODUCTION

Incisional hernia is a common complication of abdominal surgery with multifactorial aetiology.[1,2] It can cause significant morbidity, impair quality of life, and are costly to treat.[2] Currently, the intra-abdominal technique with Composite mesh (CM) is considered the gold standard for its defect closure, as it effectively withstands intra-abdominal pressure and has a low risk of gastrointestinal adhesions.[3] It has its "biface implants" with a porous external surface to encourage tissue integration and a smooth microporous internal surface to prevent adhesions when placed in contact with viscera. Pedicled omental patch is widely used to close several defects on the abdomen, as it can promote wound healing. However, pedicled omental patch is limited in range. The using of free omental patch had been studied for the defect closure of farther distance of intraabdominal defect, such as perforated gastric or duodenal ulcer.[4] However, the usage of free omental patch to close the defect of incisional hernia need to be studied.

This study aims to compare the efficacy of free omental patch, combination of polypropylene mesh with free omental patch, and composite mesh in the closure of incisional hernia defects. We evaluated wound healing by assessing the expression of Vascular Endothelial Growth Factor (VEGF), COL3A1, COL1A1, COL1A2, and COL1A1/COL3A1 ratio which are involved in proliferative and remodelling stage of wound healing by inducing angiogenesis, tissue fibrosis, and collagen formation.[5-7]

MATERIALS AND METHODS

This study was conducted for seven months, from May 2023 to December 2023. A total of 18 male albino Wistar rats *(Rattus norvegicus)* with a body weight (BW) of 275-300 grams and age of two to three months were obtained from the experimental animal development unit at Universitas Gadjah Mada. They were made into incisional hernia models within 14 days. Furthermore, the subjects were divided into three groups with different defect closure method using free omental patch (FOP), polypropylene mesh plus free omental patch (FOP-PPM), and composite mesh (CM). The polypropylene mesh PPM used in this study was a polypropylene knitted mesh, which was non-absorbable, light weight, large pore (1.3 x 1.1 mm), thickness 0.43 mm, and burst strength 585 kPa. The CM used in this study was a macroporous, partially absorbable, tissue-separating mesh, combining large-pore mesh knitted with monofilament fibers and natural absorbable tissue separating technology. Abdominal wall wound was excised using Metzenbaum and the sample was taken from 3 separated site from it to see the expression of qPCR of VEGF, COL3A1, COL1A1, and COL1A2 after 21th day. This study has received approval from The

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Corresponding Author: Imam Sofii
Email: imam.sofii@ugm.ac.id

Table I: Expression of VEGF and collagen in the usage of Polypropylene Mesh-Free Omental Patch (PPM-FOP) compared to Composite Mesh (CM)

	PPM – FOP		CM		p-value
	Average	SD	Average	SD	
VEGF	0.09	0.125	0.217	0.254	0.79
COL3A1	1.34	1.607	2.22	2.236	0.96
COL1A1	1.29	1.256	1.52	0.965	0.98
COL1A2	0.10	0.125	0.22	0.254	0.77
COL1A1/COL3A1	1.02	1.281	1.46	2.317	0.08

Table II: Expression of VEGF and Collagen in the usage of Free Omental Patch (FOP) compared to Composite Mesh (CM)

	FOP		CM		p-value
	Average	SD	Average	SD	
VEGF	0.066	0.076	0.217	0.254	0.315
COL3A1	1.3	1.658	2.22	2.236	0.898
COL1A1	0.95	0.895	1.52	0.965	0.558
COL1A2	0.067	0.076	0.22	0.254	0.315
COL1A1/COL3A1	1.36	1.862	1.46	2.31	0.187

Medical and Health Research Ethics Committee of the Faculty of Medicine, Public Health, and Nursing at Gadjah Mada University with the Ethical Clearance number: KE/FK/1174/EC/2023 and animal welfare.

Incisional hernia model

All subjects were sedated using diazepam 25 mg/kgBW and ketamine 2.5 mg/kgBW. The abdominal region was prepared and shaved. Aseptic procedure was performed using povidone iodine followed by 2 cm of median incision until the fascia and peritoneum (Figure 1). Fascia was left opened and the skin was sutured using a monofilament non-absorbable suture 4.0. After 14 days, the hernia incisional model was successfully obtained (Figure 2).

Defect closure

A 2 cm of abdominal incision was performed at the lateral side of the incisional hernia until fascia and peritoneum. The defect was identified and closed with FOP, FOP plus PPM, and CM by sublay method at the preperitoneal space. The fixation was using running suture with multifilament absorbable 4.0. The abdominoplasty was performed using monofilament non-absorbable 4.0 with simple continuous running suture.

Statistical analysis

The analysis was performed with SPSS 23 on Microsoft Windows 11. Normality test was assessed using the Shapiro-Wilk test. Student t-test was performed to compared the expression of VEGF, COL3A1, COL1A1, COL1A2 and COL1A1/ COL3A1 ratio, between FOP, FOP-PPM, and CM all at a 95% confidence level.

RESULTS

All 18 test subjects underwent all stage of the test, from the make of hernia model, hernia closure, until termination and the qPCR test of the abdominal wall tissue. No dead, infected, nor ill subject during the study. The experimental results are shown in Table I and Table II.

As shown in Table I and Table II in the terms of VEGF expression, there were no difference in the usage of FOP-PPM compared to the CM with the p-value of 0.79 ($p>0.05$), nor between the FOP alone compared to the CM with the p-value of 0.315 ($p>0.05$). Similar results showed in Collagen expression, where there was no difference in the usage of FOP-PPM compared to the CM in all the Collagen type tested, COL3A1, COL1A1, and COL1A2 with the p-value of 0.96, 0.98, and 0.77 ($p>0.05$) respectively, nor between the FOP alone compared to the CM with the p-value of 0.898, 0.558, and 0.315 ($p>0.05$) respectively. In addition, there was also no significant difference of COL1A1/ COL3A1 ratio either between the FOP compared to the CM, or FOP-PPM compared to the CM.

DISCUSSION

Incisional hernia can be repaired by various procedure. Direct closure using Mayo technique can be used to close the defect. However, the recurrence percentage is high and can only be applied for small defect.[9] Defect closure using mesh can be performed for larger defect with less recurrence. However, the using of mesh, especially PPM can promote intraabdominal adhesion. CM is the current "gold standard" for defect closure of incisional hernia due to its "biface implants" with a porous external surface to encourage tissue integration and a smooth microporous internal surface to prevent adhesions when placed in contact with viscera.[10] However, CM is relatively high in price and not widely available in developing countries.

The utilization of PPM plus fresh amniotic sac for the closure of hernia defects in rats demonstrated noteworthy outcomes in the mitigation of the risk of adhesions. This was achieved by reducing postoperative inflammation and enhancing the

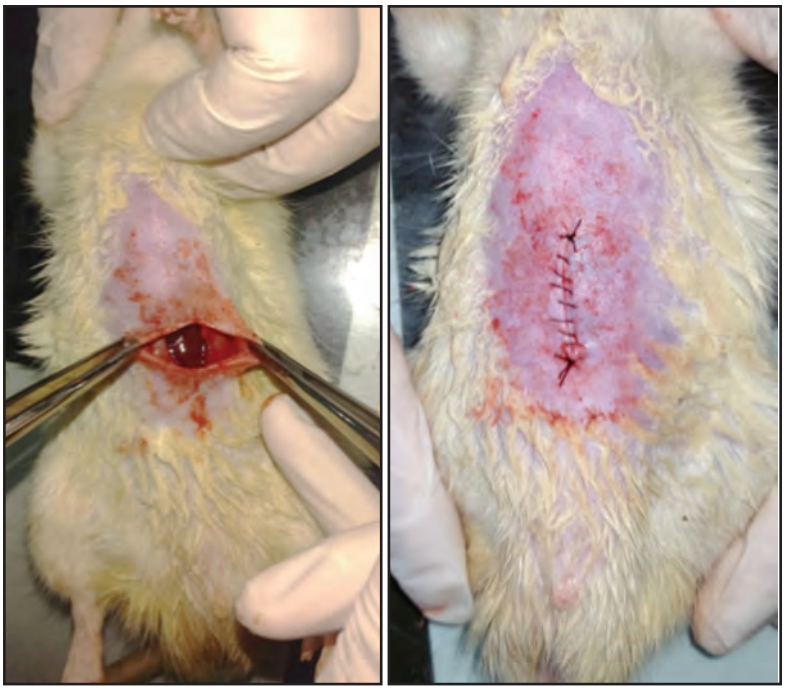

Fig. 1: Midline incision for hernia model

Fig. 2: Hernia incisional model after the 14th day

epithelialization process, which is a crucial step in the wound healing cascade. In the context of this study, PPM plus FOP demonstrated its ability to be equivalent to CM in accelerating wound healing. This was evidenced through the increased expression of several key biomarkers, including VEGF, COL3A1, COL1A1, COL1A2 and COL1A1/ COL3A1 ratio, which all play important roles in the process of tissue regeneration.[11]

Vascular endothelial growth factor (VEGF) is crucial for angiogenesis, the process of new blood vessel formation, which is essential for delivering nutrients and oxygen to healing tissues. VEGF drives several steps in the angiogenic cascade, including the migration and proliferation of endothelial cells, which are vital for forming new blood vessels at the wound site. This process enhances tissue perfusion, facilitating better healing outcomes. VEGF also stimulates the deposition of collagen types I and II, as well as

epithelial cell migration, contributing to structural integrity and wound closure.[12]

Collagen type III alpha 1 (COL3A1) plays a significant role in the context of hernia repair, particularly in understanding the mechanisms underlying hernia formation and recurrence. An imbalance between collagen types I and III is a critical factor in the mechanical stability of connective tissue. A decreased ratio of type I to type III collagen (COL1A1/ COL3A1 ratio) has been observed in patients with inguinal and incisional hernias, which may lead to mesh instability and increased hernia recurrence rates. This imbalance arises from an increase in immature type III collagen, which is mechanically less stable than mature type I collagen.[13]

The combination of hernia mesh and omentum has been demonstrated to markedly enhance the safety and efficacy of hernia repair. The placement of the omentum between the visceral and polypropylene mesh can effectively prevent complications associated with direct contact between the mesh and internal tissues, such as adhesion and infection. This approach not only reduces the risk of mesh-related problems, but also contributes to better repair outcomes. Furthermore, the use of the omentum in hernia repair has been associated with reduced recurrence rates and postoperative complications, especially in complex hernia cases and emergency situations where a quick and effective repair is essential.[14]

The findings of this study indicate that both defect closure using FOP and MPP-FOP exhibit comparable efficacy to MC in the context of wound healing. This was demonstrated through the non-significant different in the expression of VEGF, COL3A1, COL1A1, COL1A2, and COL1A1/COL3A1 ratio between those treatment option. These findings confirm the potential use of FOP, either alone or combined with PPM, as an effective alternative in incisional hernia defect closure surgery.[15]

The limitation of this study was that only one side of the abdominal wall was harvested. We just harvest the abdominal wall once, three weeks after defect closure then sacrifice the rats. We only use 2 meshes type: PPM and CM. This study focuses on wound healing process, we did not measure the tensile strength and biomechanical of hernia mesh.

CONCLUSION

In this study, it was found that both FOP and FOP-PPM exhibit comparable effectiveness to MC in wound healing. This was demonstrated through the non-significant different in the expression of VEGF, COL3A1, COL1A1, COL1A2, and COL1A1/COL3A1 ratio between those treatment option. These findings confirm the potential use of FOP, either alone or combined with PPM, as an effective alternative in incisional hernia defect closure surgery.

DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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CONFLICT OF INTEREST

The authors declare they have no conflicts of interest.

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