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Hokka, Daisuke  
Tanaka, Yugo  
Shimizu, Nahoko  
Doi, Takefumi  
Maniwa, Yoshimasa

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**New  
Methods**

# Oxidized Regenerated Cellulose Sheets in Postoperative Intrathoracic Adhesions

Daisuke Hokka, MD, PhD, Yugo Tanaka, MD, PhD, Nahoko Shimizu, MD, PhD,  
Takefumi Doi, MD, PhD, and Yoshimasa Maniwa, MD, PhD

**Adhesiolysis is often necessary in intrathoracic adhesion during ipsilateral repeat lung resection. This procedure has a risk of surgical complications, including unintentional intraoperative damage of the pulmonary vessels or lung parenchyma. We used an oxidized regenerated cellulose (ORC) sheet to prevent intrathoracic adhesion after lung resection in 55 patients. The sheet was placed on the surface of the resected region and on the lung surface under the wound. No major postoperative complications were observed. Three cases underwent ipsilateral thoracic surgery for the treatment of lung malignancies, and there were no intrathoracic adhesions around the ORC sheet-covered area.**

**Keywords:** adhesion barrier, ipsilateral repeat lung resection, oxidized regenerated cellulose

## Introduction

The opportunity for repeat lung resection has increased recently according to need of treatment for the meta-chronous occurrence of primary lung cancer or lung metastasis.<sup>1)</sup> In repeat ipsilateral lung surgery, the difficulty of the surgical procedure increases if intrathoracic adhesions are present.<sup>1,2)</sup> Furthermore, there is no established method to prevent intrathoracic adhesions after lung resections. To this end, we introduce a new use for oxidized regenerated cellulose (ORC) sheets to prevent intrathoracic adhesion after lung resection.

*Division of Thoracic Surgery, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan*

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Corresponding author: Yugo Tanaka, MD, PhD. Division of Thoracic Surgery, Kobe University Graduate School of Medicine, 7-5-2 Kusunokicho, Chuou-ku, Kobe, Hyogo 650-0017, Japan  
Email: tanakay@med.kobe-u.ac.jp



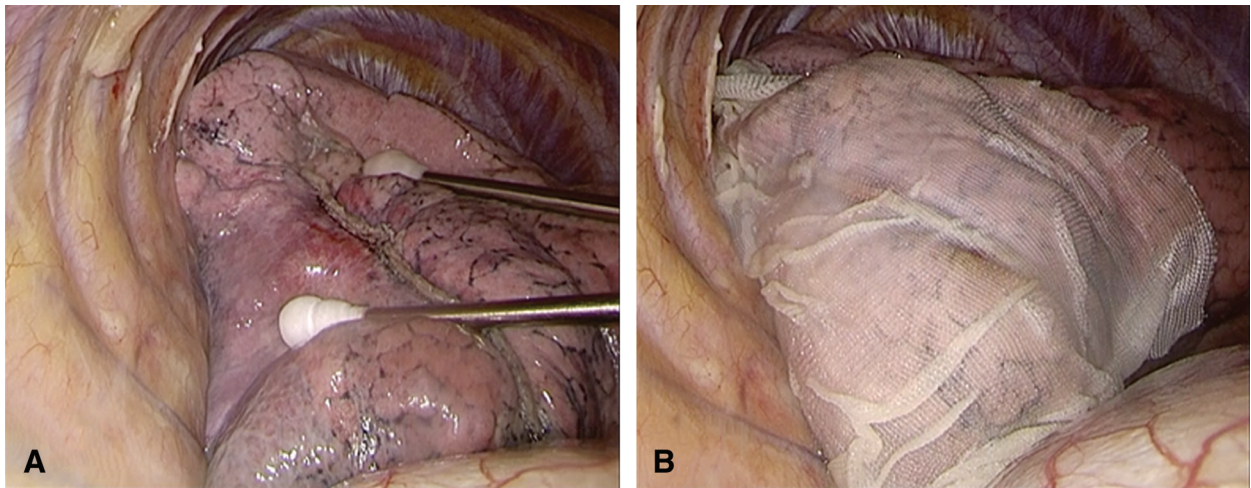
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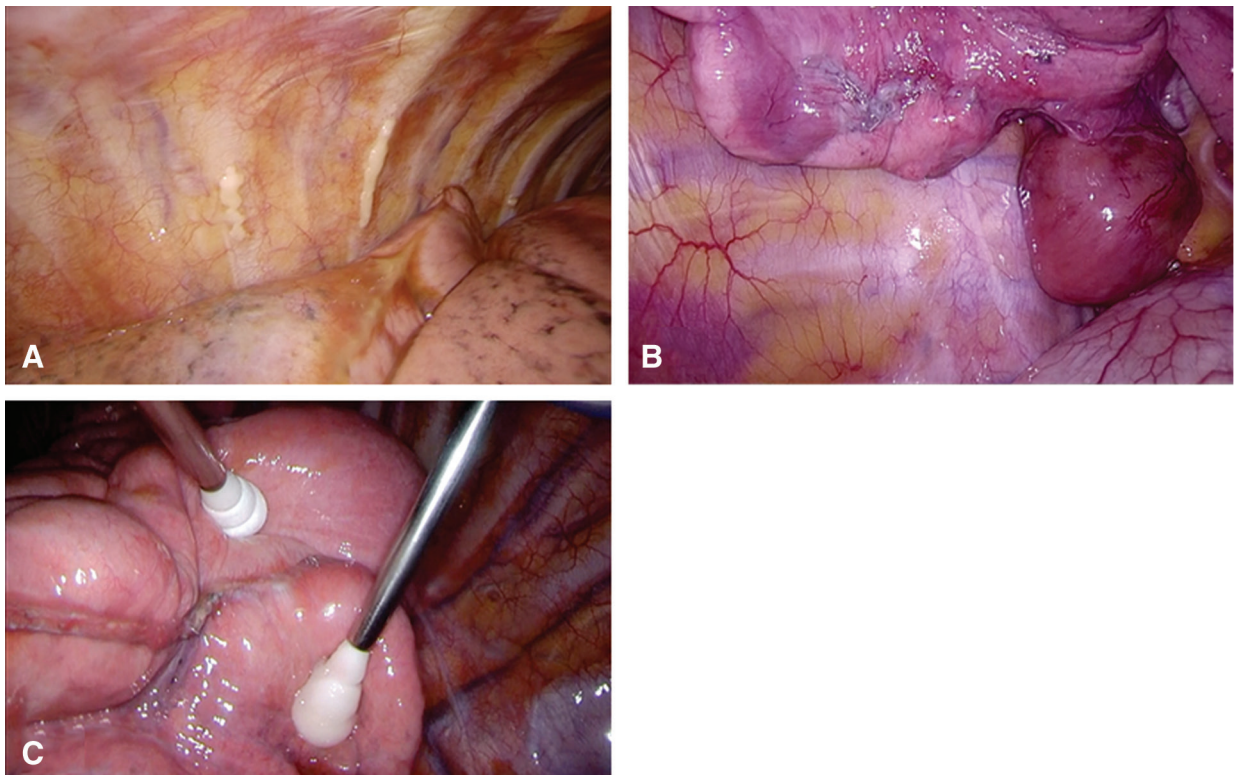
## Technique

Lung resection was performed via video-assisted thoracic surgery (VATS). Then, an ORC sheet (GYNECARE INTERCEED; Ethicon, Somerville, NJ, USA) was placed on the surface of the resected region and on the lung surface under the wound (**Fig. 1**) before closure. After the procedure, a chest drainage tube was placed and the wounds were closed.

To date, the technique of using ORC sheets to prevent adhesions in patients undergoing VATS lung wedge resection has been used in 55 patients. No major postoperative complications, including empyema and prolonged air leakage, were observed in any of the cases. The postoperative drainage fluid turned dark brown, but this was because of the low pH of the ORC sheets, which oxidized the iron in the blood, and was not due to a pathogenic mechanism. Three cases underwent ipsilateral thoracic surgery for secondary lung malignancies or additional lung resection following prior surgery where ORC sheets were used. The period from the initial surgery to the second surgery was 1, 3, and 12 months, respectively. Slight pleural thickening was observed in the area that the ORC sheet was covering in all three cases, but no adhesion between the chest wall and the lung parenchyma was observed. Therefore,



**Fig. 1** Use of an ORC sheet as an adhesion barrier in lung resection surgery. (A) Pulmonary metastasis was suspected, and lung resection was performed. (B) The resected region was covered with an ORC sheet. ORC: oxidized regenerated cellulose



**Fig. 2** Postsurgical observation of the covered region after surgery. The covered region was observed at 1 month (A), 3 months (B), and 12 months (C) after the initial surgery.

the procedure during the reoperation was unaffected by intrathoracic adhesions (**Fig. 2**).

This retrospective observational study was implemented in accordance with the principles of the Declaration of Helsinki with approval from the Clinical Research Area Ethics Committee of Kobe University Graduate School of Medicine (approval no. B200254).

## Discussion

The frequency of intrathoracic adhesion after lung resection is high and of great concern to surgeons when they perform ipsilateral lung resections for secondary lung malignancies.<sup>1,2)</sup> This is because the risk of surgical complications, such as pulmonary fistula or unexpected

intraoperative vascular damage associated with adhesion dissection, is higher in patients with intrathoracic adhesions than in those without adhesions.<sup>1)</sup> Therefore, a surgery that does not require adhesion dissection reduces the surgeon's stress as well as unnecessary tissue damage. Furthermore, the operation time is shorter, and the risk of postoperative complications is decreased.

There are no reports about the use of intrathoracic adhesion barriers because intrathoracic adhesions help to prevent pulmonary fistula after pulmonary resection. A common complication after pulmonary resection is prolonged air leakage, which is often treated by promoting adhesions between the visceral and parietal pleura.<sup>3)</sup> Thus, we consider that adhesion prevention has an adverse effect on the treatment of pulmonary fistulas and that this technique should not be used in patients with a risk of prolonged air leakage. Therefore, we only used ORC sheets in patients who underwent wedge resection, and the period until drain removal was not prolonged. Our patients did not show any obvious postoperative complications, including pneumothorax, after discharge. Considering these cases, this adhesion barrier could also be used safely for patients undergoing lobectomy or segmentectomy if they do not have fragile lung disease, such as emphysema and interstitial pneumonia.

There are some reports about the use of adhesion barriers in abdominal surgery, and several types of adhesion barriers, including ORC sheets, are often used.<sup>4-6)</sup> The ORC sheet is placed to cover the surgical site. It swells and eventually gels to form a barrier that protects it from adhesion, and it is slowly absorbed by hydrolysis within 28 days. For pneumothorax surgery, the ORC sheet is used in the thoracic cavity to reinforce the pleura rather than to prevent adhesions.<sup>7)</sup> In our three cases, slight visceral pleural thickening was observed around the ORC-covered area in repeat ipsilateral lung surgery. We consider that this change was caused by macrophages that accumulated to the ORC sheet. ORC is degraded and absorbed by the phagocytosis of macrophages.<sup>8)</sup> During tissue repair, macrophages stimulate fibroblasts, epithelial cells, and endothelial cells by the production of factors associated with wound healing.<sup>9)</sup> Therefore, we considered that the tissue repair reaction around the seat was active in our cases and that the safety of ORC sheets is guaranteed, at least for leaving it in the thoracic cavity. Additionally, we believe that more cases will benefit if the tissue-reinforcing efficacy of this sheet is demonstrated. In the future, we would like to clarify the

additional efficacy of this material, including that of tissue reinforcement.

Although we could observe the intrathoracic cavity of only three cases after the use of ORC sheets, there were no intrathoracic adhesions at the covered areas in all cases. Additionally, there was no difficulty in the re-excision of lung parenchyma covered with ORC sheets, although slight pleural thickening was observed at the covered region.

## Conclusion

We introduced a method of using an ORC sheet to prevent adhesions in the thoracic cavity. Although the safety of intrathoracic use of ORC sheet was predicted by our patients, the effect of preventing intrathoracic adhesions can only be confirmed by reoperation. Furthermore, postoperative adhesion formation does not develop in some cases where adhesion barriers are not used. Therefore, further investigation is warranted to collect data on more cases and to verify the effect.

## Disclosure Statement

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