



## Comparative Analysis of Vertical and U-Shaped Tracheostomy Incision Healing Rates: Fibroblast Cell Count Examination

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**Abstract:** Airway emergencies can significantly increase morbidity and mortality rates, necessitating prompt and accurate assessment and management. Tracheostomy, a procedure to address inadequate ventilation and upper airway obstruction, involves various techniques such as vertical and U-shaped incisions, each affecting wound healing differently. This study aimed to analyze and compare the wound healing rates of vertical versus U-shaped tracheostomy incisions in terms of fibroblast cell count. This was an experimental preclinical study utilized white rats (*Rattus norvegicus*) divided into two groups based on tracheal incision types: vertical and U-shaped. Fibroblast cell count served as the primary measure of healing, examined under a light microscope with hematoxylin-eosin staining. The results showed that the median fibroblast cell count was significantly higher in the U-shaped incision group (103.5 pg/mL) compared to the vertical incision group (25.2 pg/mL), indicating faster healing in the U-shaped incision group. In conclusion, the U-shaped tracheostomy incision demonstrates superior wound healing compared to the vertical incision, reflected by higher fibroblast cell counts. Further research is recommended to confirm these findings in clinical settings.

**Keywords:** fibroblasts; U-shaped tracheostomy; vertical tracheostomy

## INTRODUCTION

Tracheostomy is a critical intervention for patients with upper airway obstruction or inadequate ventilation. Different incision techniques can affect wound healing rates and complications.<sup>1</sup> The process of tracheostomy is not without its problems. Complications from tracheostomies include tracheal stenosis, infection, and bleeding.<sup>1</sup> Excessive granulation growth of tissue surrounding the tracheostomy stoma site as a result of abnormal wound healing is typically the cause of tracheal stenosis post tracheostomy.

As scientific knowledge advances, so do the techniques for tracheal incision in tracheostomy. Many studies have been developed to analyze the safer and more effective tracheostomy techniques in order to minimize morbidity.<sup>2</sup> Examples of incision techniques on the trachea based on the direction of the cut are vertical and U-shaped incisions, both tracheostomy incision techniques are suspected to affect the wound healing process post-tracheostomy.<sup>3</sup> Therefore, this study aimed to investigate the healing process of wounds in vertical and U-shaped tracheostomy incisions by comparing the fibroblast cell count in each type of incision. Moreover, the study identified the complications that could arise post-tracheostomy, such as bleeding, infection, and tracheal stenosis. The background information highlights the emergency conditions that necessitate quick, precise, and correct airway management, often leading to tracheostomy.<sup>1,2</sup>

## METHODS

This study was conducted at the Scientific and Biomedical Research Laboratory Manado. The aim of the study was to determine which incision technique promotes faster and better wound healing by analyzing the fibroblast cell count in the wound.

This preclinical trial involved white rats (*Rattus norvegicus*), aged 2-3 months and weighing 200-300 grams. The rats were divided into two groups: vertical incision and U-Shaped incision. After a week of acclimatization, tracheostomy was performed. The healing process was evaluated by examining the fibroblast cell count in tissue samples collected on day 16 post-surgery. Data were analyzed using the Shapiro-Wilk normality test and the Mann-Whitney test to compare fibroblast cell counts between groups. Statistical significance was set at  $p < 0.05$ .

## RESULTS

Table 1 showed that the U-shaped incision group had a significantly higher median fibroblast cell count across all observations compared to the vertical incision group, indicating a faster healing rate for the U-Shaped incision. This suggests that the U-shaped incision promotes better wound healing by attracting more fibroblast cells to the wound site. The median fibroblast count in the U-shaped incision group was 103.5 pg/mL, while the vertical incision group had a median count of 25.2 pg/mL. The difference in fibroblast cell count was statistically significant, indicating that the U-shaped incision is more effective in promoting wound healing.

**Table 1.** Number of fibroblast cells by type of tracheostomy incision

Fibroblast (pg/mL)	U-Shaped (n = 10)		Vertical (n = 10)	
	Med (Q1,Q3)		Med (Q1,Q3)	p <sup>a</sup>
Field of View I	108.5	(94.2; 116.0)	23.5	(18.0; 33.5)
Field of View II	106.0	(99.0; 142.5)	27.0	(16.2; 36.2)
Field of View III	93.0	(71.0; 99.0)	26.0	(21.2; 33.8)
Average	103.5	(89.3; 143.2)	25.2	(22.8; 28.3)

Figure 1 showed that in comparing Figure 1A and 1B, the infiltration of fibroblasts in submucosal layers were more abundant in U shaped incision with 103 fibroblast cells (Fig. 1A), meanwhile vertical incision showed only 25 fibroblasts cells (Fig. 1B).

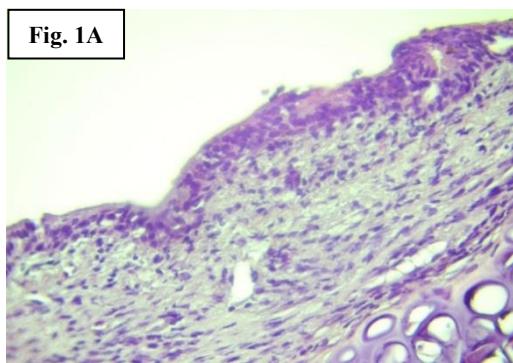


Fig. 1A

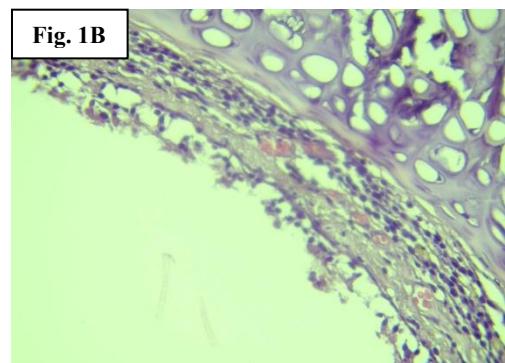
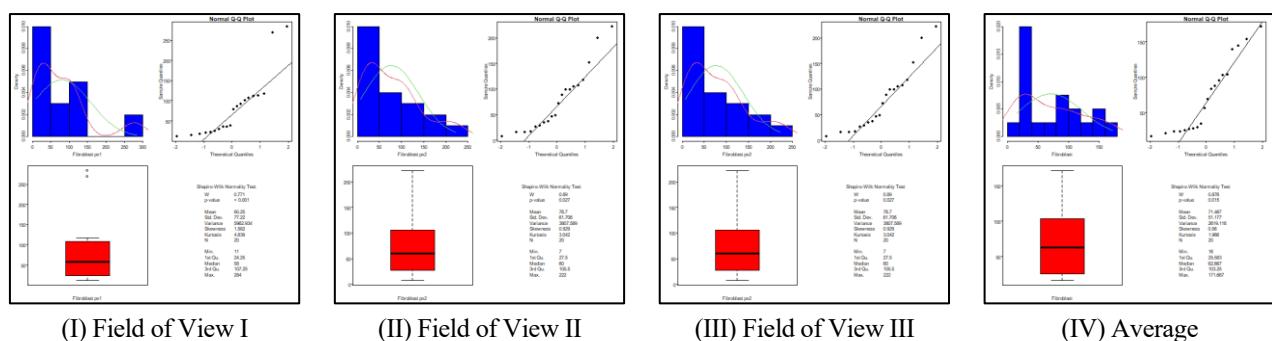


Fig. 1B

**Figure 1.** Infiltration of fibroblasts in the submucosal layer of trachea: A) U shaped incision with 103 fibroblast cell ; B) Vertical incision with 25 fibroblasts cell



**Figure 2.** Distribution of fibroblast cell counts in experimental animals

## DISCUSSION

The study found that the U-shaped incision technique results in a higher fibroblast cell count, which is crucial for wound healing. According to Cheung et al's study,<sup>1</sup> the wider incision area in the U-shaped technique likely triggered a stronger inflammatory response, attracting more cytokines and growth factors like PDGF and TGF- $\beta$ , which were essential for fibroblast recruitment. The even distribution of pressure and the preservation of tracheal structure integrity in the U-shaped incision helps to minimize tension at the wound edges, allowing for better blood flow. This enhanced blood flow delivers oxygen and nutrients required for the wound healing process.<sup>2</sup>

The findings align with existing theories and previous research indicating that U-shaped incisions are associated with better wound healing outcomes. The technique's ability to maintain blood flow and reduce tissue trauma contributes to its effectiveness.<sup>3</sup> Despite the significant findings, the study has some limitations, including the difference in the duration of the procedure between rats and humans. Based on the study by Furlow et al,<sup>5</sup> the smaller tracheal size in rats presents challenges that may not be directly applicable to human tracheostomy.<sup>4</sup> The research highlights the need for further studies to evaluate other factors influencing wound healing, such as angiogenesis, immune cell infiltration, and collagenization. These factors could provide a more comprehensive understanding of the healing process post-tracheostomy.

The study's results are promising for the U-shaped incision technique, particularly in elective tracheostomy procedures. However, the vertical incision remains the preferred choice in emergency situations due to its quicker execution and simplicity.<sup>6</sup> The significant difference in fibroblast cell count between the two techniques underscores the importance of selecting the appropriate incision method based on the clinical scenario. This decision can impact the patient's recovery and reduce the risk of complications.<sup>7</sup> The study's methodology and reliable data collection contribute to the robustness of the findings. The use of white rats as a model organism provides valuable insights, although further research involving human subjects is necessary for clinical validation based on the study by Kennedy et al.<sup>8</sup> The comparison of wound healing in vertical and U-shaped incisions offers

practical implications for surgical practice. Surgeons can consider these findings when deciding on the incision technique to optimize patient outcomes.<sup>9</sup>

A study by Lim et al<sup>2</sup> compared the outcomes of vertical and transverse skin incisions in percutaneous tracheostomy for critically ill patients. The study found that transverse incisions were associated with significantly lower incidence of complications, particularly ulcers at the tracheostomy site, compared to vertical incisions. This aligns with our findings that the U-shaped incision, which is similar to the transverse incision, promotes better wound healing. Another study by Sidam et al<sup>10</sup> assessed the outcome measures between vertical and horizontal skin incisions in tracheostomy. The study found that horizontal incisions had fewer complications within seven days post-procedure compared to vertical incisions. This supports our conclusion that the U-shaped incision, which can be considered a type of horizontal incision, is more effective in promoting wound healing. Overall, the research emphasizes the role of fibroblasts in wound healing and the effectiveness of the U-shaped incision in promoting a faster and better healing process. Future studies should explore additional aspects of wound healing to build on these findings.<sup>11</sup>

## CONCLUSION

The U-shaped tracheostomy incision technique significantly enhances wound healing compared to the vertical incision. The higher fibroblast cell count in the U-shaped incision group indicates a more robust healing response. Although the vertical incision is advantageous in emergency situations due to its speed and simplicity, the U-shaped incision provides better long-term healing outcomes. Further research is recommended to explore other factors influencing wound healing and validate the findings in human subjects.

## Conflict of Interest

The authors declare no conflict of interest in this study.

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