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Comparison of tissue reaction in primary tracheal repair using silk, monofilament absorbable (Polyglecaprone), and multifilament absorbable (Polyglactin 910) sutures (An experimental study on New Zealand rabbits)

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Abstract: Surgical interventions for tracheal trauma include repairing lacerations, reducing and closing cartilage fractures, and performing end-to-end anastomosis in cases of complete transection. One of the potential long-term complications following tracheal surgery is tracheal stenosis. The inflammatory reaction depends on the suture material used, the type of tissue being sutured, and the immune system. Several factors related to the suture material that influence the inflammatory reaction include suture absorbability, the number of filaments, suture size, and tissue reactivity to the suture. This study aimed to compare the inflammatory reaction (tissue reaction) caused by various suture materials in primary tracheal repair in male New Zealand rabbits. This experimental study employed a randomized controlled trial design, conducted on male New Zealand white rabbits. The rabbits were acclimatized for seven days, followed by permuted block randomization, dividing the samples into four groups. After the inflammatory phase (7 days), tissue reactions in the surgical area were examined post-tracheal reconstruction. Data analysis was performed using SPSS software. Each group consisted of six samples, demonstrating homogeneity in terms of age ($p = 0.93$), preoperative weight ($p = 0.87$), and postoperative weight ($p = 0.88$). Macroscopic evaluation showed no wound dehiscence, pus, or tracheal defects caused by suture displacement. Histopathological analysis revealed a significantly different degree of inflammation ($p = 0.049$) between the two treatment groups. Monofilament absorbable sutures (polyglecaprone) exhibited a lower inflammatory reaction than multifilament absorbable sutures (polyglactin 910) in primary tracheal repair, with silk sutures as the control.
Keywords: *Inflammatory reaction Polyglactin 910, Polyglecaprone, Primary tracheal repair, Silk.*

1. Introduction

Trauma to the trachea, whether sharp or blunt, requires prompt diagnosis and surgical exploration to restore tracheal function, thereby preventing complications and respiratory dysfunction. Surgical interventions for tracheal trauma include repairing lacerations, reducing and closing cartilage fractures, and performing end-to-end anastomosis in cases of complete transection. One of the long-term complications that may arise after tracheal surgery is tracheal stenosis [1-3].

Several factors influence the wound healing process in primary repair, including the suture material used, the suturing technique, and the local condition of the wound. The suture material utilized in tracheal surgery is recognized as a foreign body by the immune system, triggering an immunological response. The inflammatory reaction depends on the suture material, the type of tissue being sutured, and the immune system. Factors related to the suture material that affect the inflammatory reaction

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include suture absorbability, the number of filaments, suture size, and the tissue reactivity of the suture [4].

In a previous study conducted by Andrade, et al. [5] on the inflammatory reaction of subcutaneous tissue in rats using absorbable sutures, it was shown that each type of absorbable suture (Irradiated polyglactin 910, polydioxanone (PDS), polyglecaprone 25, and Chromic gut) induced different inflammatory reactions when used for suturing the subcutaneous tissue on the backs of test rats [5].

During the suture removal process, it was observed that absorbable multifilament sutures were easier to remove compared to absorbable monofilament sutures. Microscopically, it was found that absorbable monofilament sutures such as Chromic Gut and absorbable multifilament sutures like Irradiated polyglactin 910 caused stronger inflammatory reactions compared to other suture types in that study. However, in another study by Behrend et al., involving tracheal reconstruction in sheep, no significant difference in inflammatory reactions was observed between the use of absorbable monofilament sutures (Polydioxanone) and absorbable multifilament sutures (Polyglactin 910 and Polypropylene)[6].

Considering that tracheal stenosis complications can lead to emergency conditions and respiratory dysfunction, high-quality primary tracheal repair is essential to achieve optimal wound healing. Demonstrating the use of absorbable sutures with a low level of inflammatory reaction (tissue reaction) can provide clinical benefits in managing patients with tracheal trauma.

The aim of this study is to compare the inflammatory reaction (tissue reaction) between absorbable monofilament and multifilament sutures in primary tracheal repair, using non-absorbable multifilament sutures (silk) as a control.

2. Methods

This study is experimental research utilizing a randomized controlled trial design conducted on male New Zealand white rabbits. The rabbits were acclimated to appropriate housing and feeding conditions. The criteria for inclusion were adult male New Zealand white rabbits aged 6–9 months, weighing between 1900 and 2500 grams, without visible anatomical abnormalities, and with suturing performed using the simple interrupted technique. The rabbits were acclimatized for 7 days before being randomized into four groups using permuted block randomization. After the proliferation phase, tissue reaction evaluations were performed.

The sample size for this study was calculated using the "Federer" replication formula, resulting in a minimum of 5 samples per group. An additional 10% was added to each group, equivalent to 1 rabbit per group for potential sample loss due to mortality. Therefore, each group consisted of 6 rabbits, with a total of 18 male New Zealand white rabbits used in the study.

The sampling technique in this study involved clinical evaluation and acclimatization in a suitable environment for 7x24 hours to ensure that the animals were disease-free, had no potential for disease transmission, and were physically and mentally healthy. After screening, the samples were allocated into homogeneous groups using permuted block randomization, ensuring equal chances for each sample to be assigned to the control or treatment groups. The independent variables in this study were primary suturing with silk, monofilament sutures (polydioxanone, glyconate), and multifilament sutures (polyglactin 910), with silk sutures serving as the control. The dependent variable was the inflammatory reaction in tracheal tissue undergoing primary repair.

The procedure included rabbit preparation, treatment administration, and inflammatory reaction assessment. After a 7-day acclimatization period, randomization was performed using permuted block randomization into three groups: a control group (6 rabbits) and two treatment groups (6 rabbits each). Before undergoing treatment, the rabbits were fasted to prevent aspiration pneumonia, which could increase the risk of mortality.

After a 7-day acclimatization period, the rabbits were subjected to treatment. In the control group, tracheal wounds were closed using interrupted silk sutures. In Treatment Group 1, the tracheal wounds

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were closed using interrupted polydioxanone sutures, while in Treatment Group 2, polyglecaprone sutures were used for tracheal wound closure, followed by skin closure with 4-0 nylon sutures.

The inflammatory response was assessed using a scoring system ranging from 0 to 2, where a score of 0 indicated no inflammatory cells, 1 indicated mild inflammation, and 2 indicated severe inflammation.

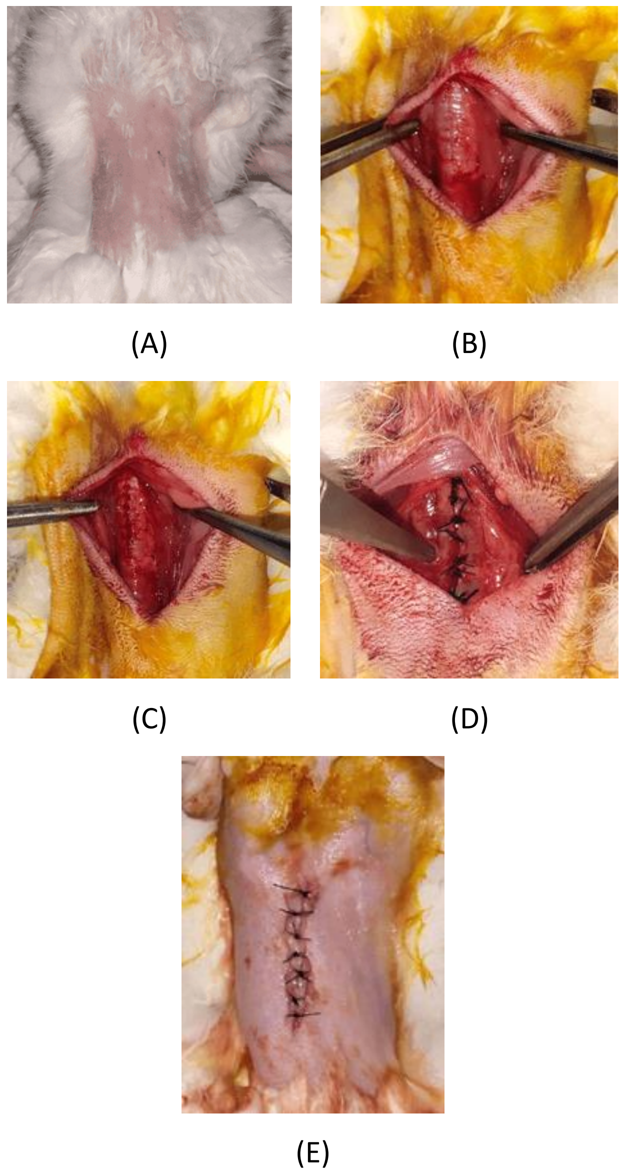

Figure 1.
Steps in Rabbit Treatment Procedure; (A) The fur on the rabbit's neck is shaved clean, (B) Tissue dissection is performed to expose the trachea, (C) A 0.6 x 0.6 cm^2 full-thickness tracheal wound is created, (D) In the control group, the tracheal wound is closed using primary interrupted sutures, (E) The skin is sutured using a simple interrupted technique with 4-0 nylon sutures.

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To ensure validity, the research variables were assessed using tools and testing materials with high sensitivity and specificity, which were consistent and reliable. Validity testing was conducted by the researcher in collaboration with a specialist in Anatomical Pathology. The data collected were ordinal and were compared between the control and treatment groups using the non-parametric Mann-Whitney U test. This study adhered to ethical research standards under Ethical Clearance No: 2.KEH.030.02.2024.

Table 1.
Characteristics of research samples.

Characteristic	Group		P value
	Control	Treatment	
Age			
Mean	7,73	7,74	0,93
Deviasion standard	1,08	1,06	
Median	8,2	8,2	
Berat sebelum tindakan (gram)			
Mean	2220	2266	0,791
Deviasion standard	262,7	244,5	
Median	2389	2406	
Berat sesudah tindakan (gram)			
Mean	2179	2221	0,93
Deviasion standard	262,8	276,2	
Median	2358	2381	

3. Results and Discussion

In this study, the mean age of the control group samples was 7.73 months, with a standard deviation of 1.08 months and a median of 8.2 months. The treatment group samples had a mean age of 7.74 months, with a standard deviation of 1.06 months and a median of 8.2 months. Statistical analysis of the age variable showed no significant difference between the control and treatment groups ($p = 0.93$).

The pre-procedure weight of the control group samples was 2,220 grams, with a standard deviation of 262.7 grams and a median of 2,389 grams. In the treatment group, the pre-procedure weight was 2,266 grams, with a standard deviation of 244.5 grams and a median of 2,406 grams. Statistical analysis of the pre-procedure weight variable showed no significant difference between the control and treatment groups ($p = 0.791$).

The post-procedure weight of the control group samples had a mean of 2,179 grams, with a standard deviation of 262.8 grams and a median of 2,358 grams. In the treatment group, the post-procedure weight had a mean of 2,221 grams, with a standard deviation of 276.2 grams and a median of 2,381 grams. Statistical analysis showed no significant difference in post-procedure weight between the control and treatment groups ($p = 0.93$).

3.1. Results of Inflammation Grade Assessment in the Control and Treatment Groups

The degree of inflammation was evaluated in five different microscopic fields. In the control group using silk sutures, 2 samples exhibited grade 1 inflammation, while 4 samples exhibited grade 2 inflammation. In the treatment group using polyglecaprone sutures, 4 out of 6 samples displayed grade 2 inflammation. Meanwhile, in the treatment group using polyglactin 910 sutures, all 6 samples exhibited grade 2 inflammation.

Table 2.
Degree of inflammation in the control group (Silk).

Rabbit code	Suture type	Degree of inflammation
A	Silk	2
B	Silk	2
C	Silk	2
D	Silk	1
E	Silk	2
F	Silk	1

Table 3.
Degree of inflammation in treatment group 1 (*polyglecaprone*).

Rabbit code	Suture type	Degree of inflammation
G	Polyglecaprone	2
H	Polyglecaprone	1
I	Polyglecaprone	1
J	Polyglecaprone	2
K	Polyglecaprone	2
L	Polyglecaprone	2

Table 4.
Degree of inflammation in treatment group 2 (*polyglactin 910*).

Rabbit code	Suture type	Degree of Inflammation
M	Polyglactin 910	2
N	Polyglactin 910	2
O	Polyglactin 910	2
P	Polyglactin 910	2
Q	Polyglactin 910	2
R	Polyglactin 910	2

3.2. Comparison of Inflammation Grades Between the Silk and Polyglecaprone Groups

Researchers analyzed the comparison of inflammation grades between the control group using silk sutures and the treatment group using polyglecaprone sutures. The control group had a mean inflammation grade of 1.33 ± 0.55, while the treatment group had a mean inflammation grade of 1.77 ± 0.74. Statistical analysis of the mean inflammation grades between these two groups showed no significant difference ($p = 0.593$).

Table 5.
Comparison of Inflammation Grades Between the Silk and Polyglecaprone Groups.

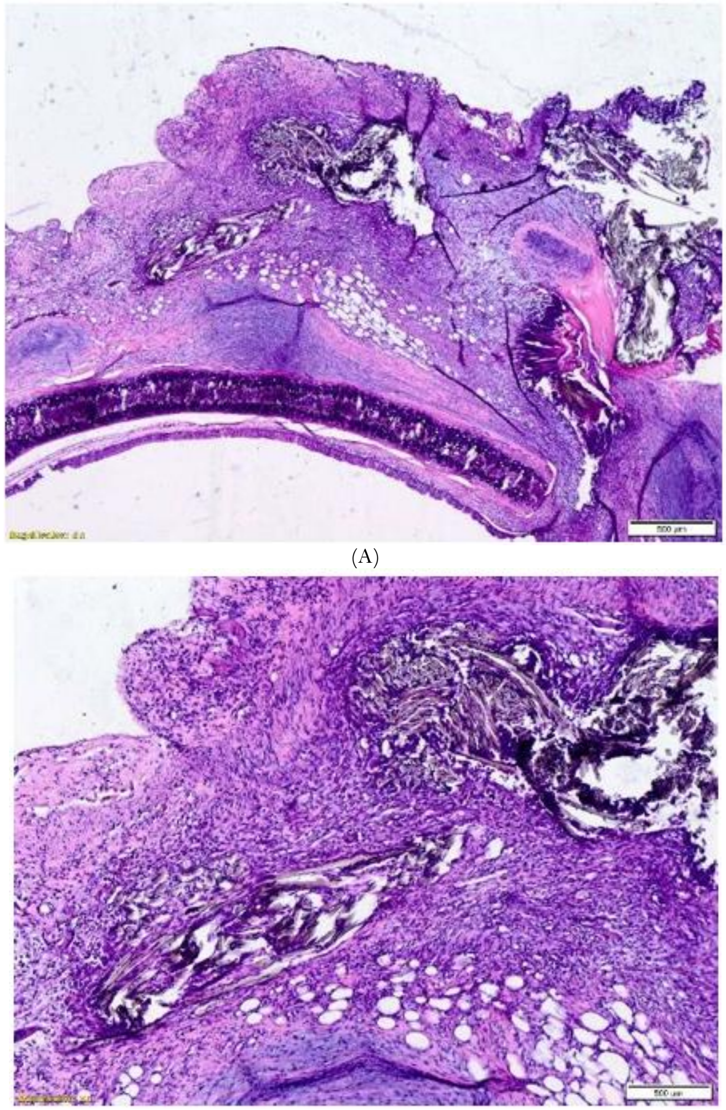
Group	Degree of inflammation (Mean ± SD)	P value
Silk	1.33 ± 0.50	0.593
Monosyn	1.77 ± 0.44	

3.3. Comparison of Inflammation Grades Between the Silk and Polyglactin 910 Groups

Researchers analyzed the comparison of inflammation grades between the control group using silk sutures and the treatment group using polyglactin 910 sutures. The control group had a mean inflammation grade of 1.37 ± 0.51, while the treatment group had a mean inflammation grade of 1.75 ± 0.46. Statistical analysis of the mean inflammation grades between these two groups revealed a significant difference ($p = 0.049$).

Table 6.
Comparison of Inflammation Grades Between the Silk and Polyglactin 910 Groups.

Group	Degree of inflammation (Mean ± SD)	P value
Silk	1.37 ± 0.51	0.049
Polyglactin 910	1.75 ± 0.46	



(A)

(B)

Figure 2.
Microscopic Images of Silk Sutures (A): Magnification 50x, (B): Magnification 200x.

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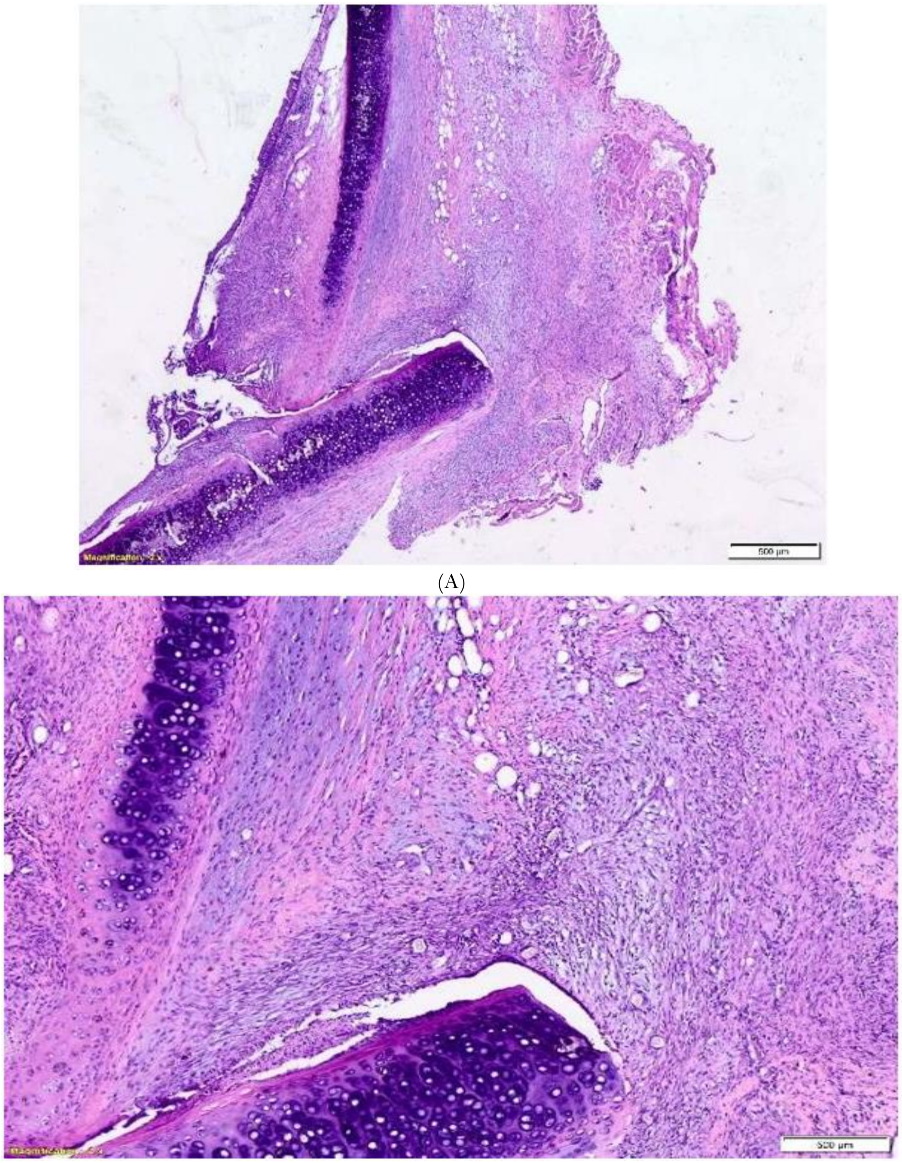

(A)

(B)

Figure 3.
Microscopic Images of Polyglecaprone Sutures, (A): Magnification 50x, (B): Magnification 200x.

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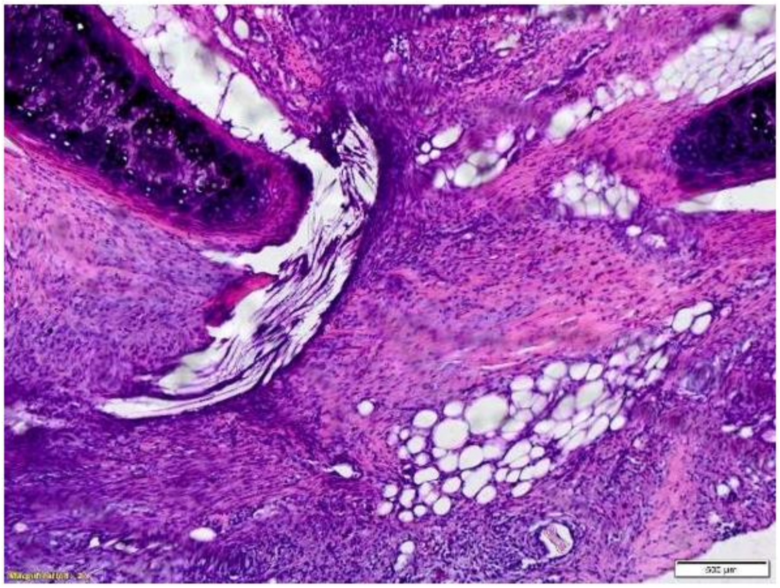
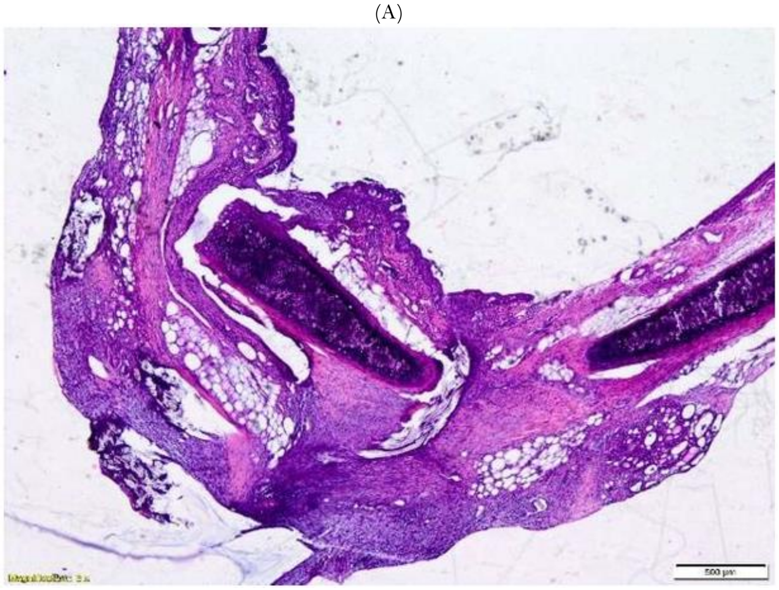


(A)



(B)

Figure 4.
Microscopic Images of Polyglactin 910 Sutures, (A): Magnification 50x, (B): Magnification 200x.

The results of this study indicate that for most observed variables, there were no statistically significant differences between the control group using silk sutures and the treatment groups using polyglecaprone or polyglactin 910 sutures. However, a significant difference was observed in the degree of inflammation between the silk and polyglactin 910 groups.The findings suggest that absorbable monofilament sutures (monosyn) and multifilament sutures (vicryl) induce a higher inflammatory reaction compared to non-absorbable multifilament sutures (silk).

Absorbable sutures can be classified as natural (e.g., surgical gut) or synthetic materials, such as Polyglactin 910, Poliglecaprone 25, and Polydioxanone. Polyglactin 910, one of the most commonly used absorbable sutures for internal tissue suturing, is known for its predictable tensile strength retention and lower tissue reaction compared to natural surgical gut (e.g., plain catgut). An early example introduced to the market in 1974 was the Vicryl brand, a braided, naturally absorbable suture, later modified in 1979 to enhance tissue passage, handling, and knot security. The raw material of Vicryl sutures is a copolymer of lactate and glycolate, coated with polyglactin 370 and calcium stearate. These sutures are absorbed through hydrolysis, with 75% tensile strength remaining at two weeks, 25% at one month, and complete absorption within 56 to 70 days, making them suitable for soft tissue approximation [7].

Additionally, a similar braided suture without dye, treated with gamma radiation to reduce molecular weight, was developed under the Vicryl Rapide brand. This variant absorbs faster, with 50% tensile strength lost by day five and complete absorption within six weeks. It is particularly ideal for short-term wound closure in superficial soft tissue mucosa and skin [7].

Poliglecaprone sutures, introduced in 1993, are synthetic sutures specifically designed for skin closure. They retain most of their tensile strength for one week and are fully absorbed within 91 to 119 days. These sutures have become a primary choice for various subcuticular skin closures, including abdominoplasty, flap insertions, and breast wound closures.[7]

The results of this study demonstrated that the degree of inflammation in the control group using silk sutures was lower compared to the groups using polyglecaprone and polyglactin 910 sutures. In the polyglecaprone group, approximately 60% of the samples exhibited grade 2 inflammation, whereas in the polyglactin group, all samples (100%) displayed grade 2 inflammation.

This indicates that absorbable sutures, whether monofilament or multifilament, tend to induce a higher inflammatory reaction compared to non-absorbable sutures like silk. Previous studies have highlighted the clinical advantages of absorbable sutures, such as avoiding the discomfort of postoperative suture removal. However, these sutures may cause greater inflammation due to enzymatic degradation and phagocytosis of the suture material. In this study, no significant differences were found between absorbable and non-absorbable sutures in terms of inflammatory cell presence on the 7th postoperative day [8, 9].

These results are not consistent with the findings of Selvi, et al. [10] who observed that silk sutures elicited a higher foreign body reaction compared to other materials. Furthermore, their study also reported that polypropylene, a synthetic monofilament non-absorbable suture, did not exhibit a severe foreign body reaction on the 7th postoperative day. This aligns with previous literature indicating that monofilament sutures generally cause a lower tissue reaction compared to multifilament sutures [10].

Denis et al. also found that bacterial adhesion was higher on absorbable sutures compared to non-absorbable ones, with polyglactin 910 multifilament material exhibiting the greatest bacterial adhesion among the tested sutures. This was attributed to the braided structure of multifilament sutures, which provides spaces for bacterial accumulation.

Several studies have confirmed that inflammatory responses are reduced when monofilament sutures are used for mucosal wounds compared to multifilament sutures. However, many clinicians still prefer multifilament sutures due to their easier handling and less sharp edges, which minimize irritation to mucosal tissues.

Additionally, other studies have suggested that wound infections can depend on both the material and structure of the sutures, but they are not exclusively determined by whether the sutures are monofilament or multifilament [4].

Various factors influence the selection of materials for wound closure, including the degradation process of the suture. The gradual and linear decrease in tensile strength of absorbable sutures during the early stages of healing is a critical consideration. During this period, leukocyte-mediated cellular responses occur to remove cellular debris and physical suture material. This phase overlaps with a secondary stage in which the majority of the suture mass is degraded.

Infections or protein deficiencies can disrupt this process, leading to a rapid decline in tensile strength and potentially resulting in wound dehiscence. Sutures that degrade via hydrolysis tend to induce a lower tissue reaction compared to those that degrade through enzymatic processes [6].

Conversely, in vivo tissue responses around non-degradable materials involve fibroblasts encapsulating the suture with fibrous tissue. Macrophages and giant cells attempt to degrade non-degradable sutures via phagocytosis, although these materials are resistant to enzymatic breakdown [11].

The findings of this study provide a general overview of the clinical implications for suture selection in tracheal surgery. Considering the lower degree of inflammation observed with silk sutures, the use of non-absorbable multifilament sutures, such as silk, may be preferable for reducing inflammatory reactions. However, absorbable sutures still offer advantages, including their ability to be absorbed and reduce the long-term presence of foreign material in the tissue. These benefits come with the trade-off of a higher risk of inflammatory responses [11].

This study has several limitations, categorized into macroscopic and microscopic constraints:

1. Limited sample size.
2. Small sample size per group.
3. Variability in tracheal sample harvesting due to operator-dependent factors (e.g., uneven slicing).
4. Time constraints that may affect the conclusions drawn.

Microscopis limitation contains:

1. Overlapping appearances of inflammatory cells under the microscope, which may not fully represent the overall inflammatory response.

Further studies are required with larger sample sizes, longer evaluation intervals, and the inclusion of additional inflammatory markers to enhance the understanding of tissue inflammatory reactions to different suture types.

4. Conclusion

Based on the findings of this study, it can be concluded that the inflammatory reaction induced by absorbable monofilament sutures (polyglecaprone) is slightly lower compared to absorbable multifilament sutures (polyglactin 910). Additionally, the inflammatory reaction observed with non-absorbable multifilament sutures (silk) is not significantly different from that of absorbable monofilament sutures (polyglecaprone).

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References

[1] R. Sjamsuhidajat and W. De Jong, *Sjamsuhidajat-de Jong's surgical textbook: Organ systems and surgical procedures*, 4th ed. Jakarta: ECG, 2017.

[2] L. M. Santiago-Rosado, D. F. Sigmon, and C. S. Lewison, "Tracheal trauma. In StatPearls," Retrieved: https://www.ncbi.nlm.nih.gov/books/NBK500015/. [Accessed 2023.

[3] A. N. Hidayati, M. I. A. Akbar, and A. N. Rosyid, *Medical and surgical emergencies*. Surabaya, Indonesia: Airlangga University Press, 2018.

[4] W. H. Titley-Diaz, "Suture Hypersensitivity. In StatPearls," Retrieved: https://www.ncbi.nlm.nih.gov/books/NBK562288/. [Accessed 2022.

[5] M. G. Andrade, R. Weissman, and S. R. Reis, "Tissue reaction and surface morphology of absorbable sutures after in vivo exposure," *Journal of Materials Science: Materials in Medicine*, vol. 17, no. 10, pp. 949-961, 2006. https://doi.org/10.1007/s10856-006-0185-8

[6] M. Behrend and J. Klempnauer, "Influence of suture material and technique on end-to-end reconstruction in tracheal surgery: an experimental study in sheep," *European Surgical Research*, vol. 33, no. 3, pp. 210-216, 2001. https://doi.org/10.1159/000049708

[7] G. Banche *et al.*, "Microbial adherence on various intraoral suture materials in patients undergoing dental surgery," *Journal of Oral and Maxillofacial Surgery*, vol. 65, no. 8, pp. 1503-1507, 2007. https://doi.org/10.1016/j.joms.2006.10.066

[8] F. Sortino, E. Pedullà, and V. Masoli, "The piezoelectric and rotatory osteotomy technique in impacted third molar surgery: Comparison of postoperative recovery," *Journal of Oral and Maxillofacial Surgery*, vol. 66, no. 12, pp. 2444-2448, 2008. https://doi.org/10.1016/j.joms.2008.06.004

[9] M. Muglali, N. Ylmaz, S. Inal, and T. Guvenc, "Immunohistochemical comparison of indermil with traditional suture materials in dental surgery," *Journal of Craniofacial Surgery*, vol. 22, no. 5, pp. 1875-1879, 2011. https://doi.org/10.1097/scs.0b013e31822e8419

[10] F. Selvi *et al.*, "Effects of different suture materials on tissue healing," *Journal of Istanbul University Faculty of Dentistry*, vol. 50, no. 1, p. 35, 2016. https://doi.org/10.17096/jiufd.79438

[11] K. A. McCall, C.-c. Huang, and C. A. Fierke, "Function and mechanism of zinc metalloenzymes," *The Journal of Nutrition*, vol. 130, no. 5, pp. 1437S-1446S, 2000. https://doi.org/10.1093/jn/130.5.1437S