

**ORIGINAL RESEARCH**

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**Percutaneous tracheostomy: An evaluation of the damage to cartilage tissue caused by the multiple dilatation method and the controlled rotating dilation technique****Cigdem Unal Kantekin<sup>1</sup>, Zuleyha Doganyigit<sup>2</sup>**<sup>1</sup>*Bozok University, Faculty of Medicine, Department of Anesthesiology and Reanimation, Yozgat, Turkey*<sup>2</sup>*Bozok University, Faculty of Medicine, Department of Histology and Embryology, Yozgat, Turkey*

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**Abstract**

The aim of this study was to investigate the tissue damage created by the two commonly used percutaneous tracheostomy methods of multiple dilatational tracheostomy and the controlled rotating dilation technique. A total of 21 sheep trachea samples were obtained from the slaughterhouse. The tracheas were separated into 3 groups of 7 samples in each. In Group 1, only an incision was made. In Group 2, the multiple dilatational tracheostomy method was applied, and in Group 3, the controlled rotating dilation technique. The tissue samples taken were separated into 2 equal pieces. One piece was used for histopathological examination and the other was examined under electron microscope. When the hematoxylin-eosin staining results and the electron microscope images of the sheep trachea slices were evaluated, cartilage integrity was observed to have been preserved in Groups 1 and 2. In Group 3, there was seen to be epithelial injury and disruption of the cartilage integrity. To reduce the complications of percutaneous tracheostomy techniques to a minimum, the protection of tissue integrity is important. The multiple dilatational tracheostomy method was seen to be superior to the controlled rotating dilation technique in respect of protecting tissue integrity.

**Keywords:** Percutaneous tracheostomy, tissue damage, multiple dilatational tracheostomy, controlled rotating dilation technique**Introduction**

Percutaneous tracheostomy (PT) is a widely used procedure for the long-term ventilation of critically ill patients [1]. As preliminary data of safety became available, and the feasibility of performing PT in the intensive care unit became more obvious, PT has primarily been shown to be a safe alternative to surgical tracheostomy [2]. Data regarding the outcome of both techniques are conflicting, probably because of the heterogeneity of the PT techniques used, and the lack of uniformity in defining and detecting some of the complications, such as tracheal stenosis [2].

A number of techniques have been developed for PT [3]. Two of these techniques are multiple dilatational tracheostomy (MDT) and controlled rotating dilation technique (CRDT).

Many articles have reported benefits of percutaneous dilatational techniques, such as simplicity, smaller skin incision, less tissue

trauma, lower incidence of wound infection, lower incidence of peristomal bleeding, and decreased morbidity. The procedure is also cost-effective, as it does not require operating room resources and may be faster to perform [4,5]. CRDT involves use of a single-step screw-type dilator. The dilator is rotated clock wise using a lifting motion over the guidewire [6].

The aim of this study was to evaluate histologically and with electron microscopy the injury to cartilage tissue in sheep trachea created by two widely used tracheostomy methods. The results of these evaluations could be of guidance in the selection of the method to be used which would reduce complications by protecting tissue integrity.

**Material and Methods****Trachea specimens**

As the trachea samples were collected from a slaughterhouse, there was no necessity for ethics committee approval according to the legal requirements. Trachea samples from 21 sheep aged 12 months, all of which were born on the same day on the same farm, were collected by the attending veterinary surgeon of the

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slaughterhouse. To eliminate the effect of environmental factors, the samples were placed in saline solution (0.85% NaCl) and transported to the Anesthesiology Department. All the procedures were applied by a single, experienced anaesthesiologist who was blinded to the study.

### Percutaneous Tracheostomy Methods

The insertion point was determined as the space between the 2nd and 3rd tracheal rings. While fixing the trachea, a 14-G needle attached to a 5-mL syringe filled with 2.5 mL of normal saline was directed to the trachea while aspirating with constant power. After confirming correct placement with observation of bubbles, the syringe was removed and a J guide wire was transferred to the trachea through the catheter over the needle. From that point, two different tracheostomy techniques were used.

**Group 1 (Control group):** Only an incision was made with no tracheostomy procedure (Figure 1a).

**Group 2 (MDT group):** A modified Seldinger technique was used for MDT. Multiple tracheal dilators were used sequentially over the J guide wire to dilate the tracheal stoma. Following the insertion of the 34-Fr dilator, an 8.0-mm tracheostomy tube was inserted using a 28-Fr loading dilator (Figure 1b).

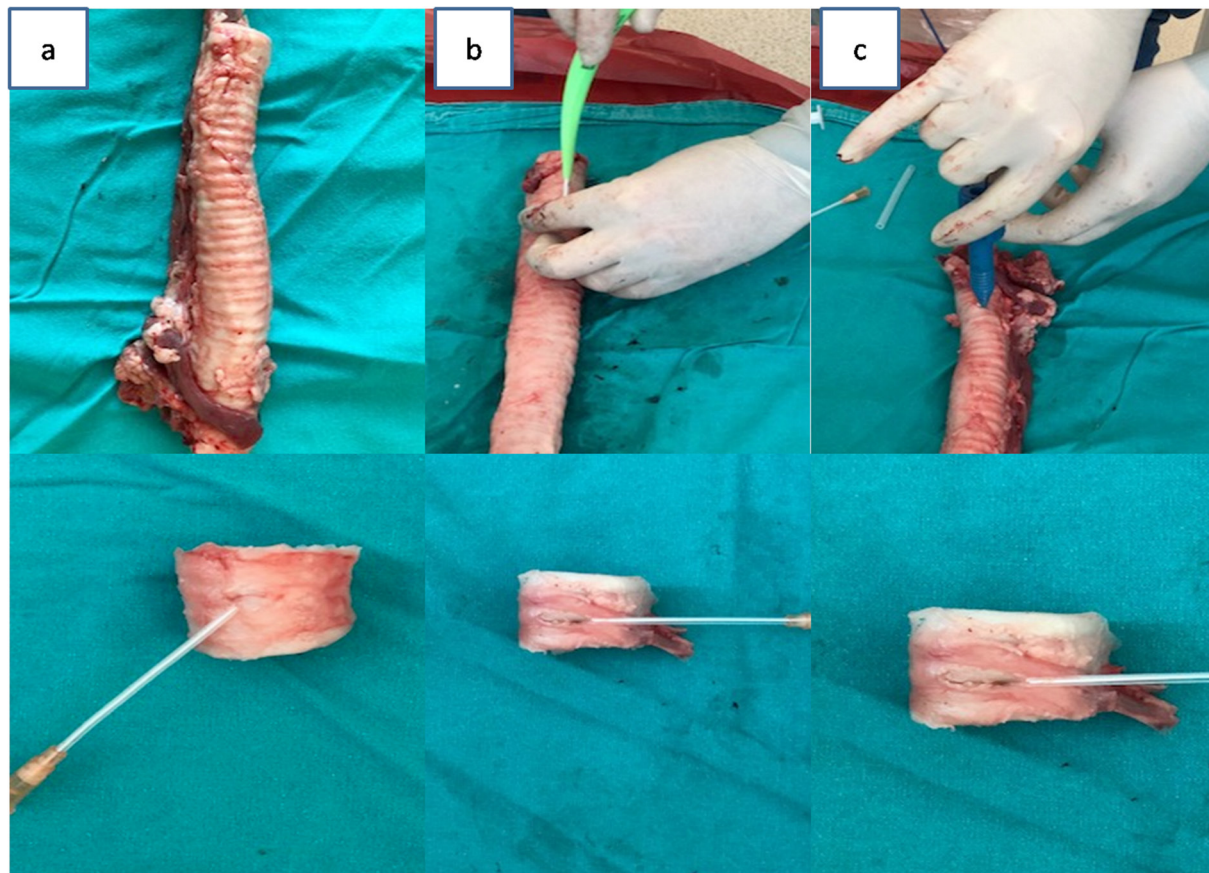
**Group 3 (CRDT group):** The Percu Twist screw dilator was placed over the guide wire via its central lumen and was advanced by clockwise rotation using Seldinger's technique. After removing

the screw dilator using counterclockwise rotation, an 8.0-mm tracheostomy tube, preloaded on to its introducer, was fed into the trachea via the guide wire (Figure 1c).

After placing the tracheostomy tube in all groups, the guide wire and introducer or trocar were removed. Each tissue sample obtained was separated into two equal parts, one half to be used for histopathological examination and the other for examination with electron microscope.

The tissue samples to be used in the histological analyses were fixed in a 10% formaldehyde solution. Routine tissue examination stages were applied to the tissues, and they were embedded in paraffin blocks. Cross-sections of the paraffin blocks with thicknesses of 5-6  $\mu$ m were stained with hematoxylin and eosin and examined under an Olympus BX51 microscope. Taking a series of slices from the blocks of all the groups, histopathological analyses were performed and suitable photographs were selected. The procedure was applied by two, experienced histologist who was blinded to the study.

**Electron Microscopy;** The texture was analyzed with a Field Emission-Environmental Scanning Electron Microscope-Energy Distribution Spectrometer (FE-ESEM-EDS) (FEI, Quanta FEG 450). The samples were applied with a drying procedure at 37°C for 1 day. Each tissue sample was placed on the device platform and fixed. Subsequently, imaging analysis of the sample was performed as either low or high vacuum at x100 magnification.



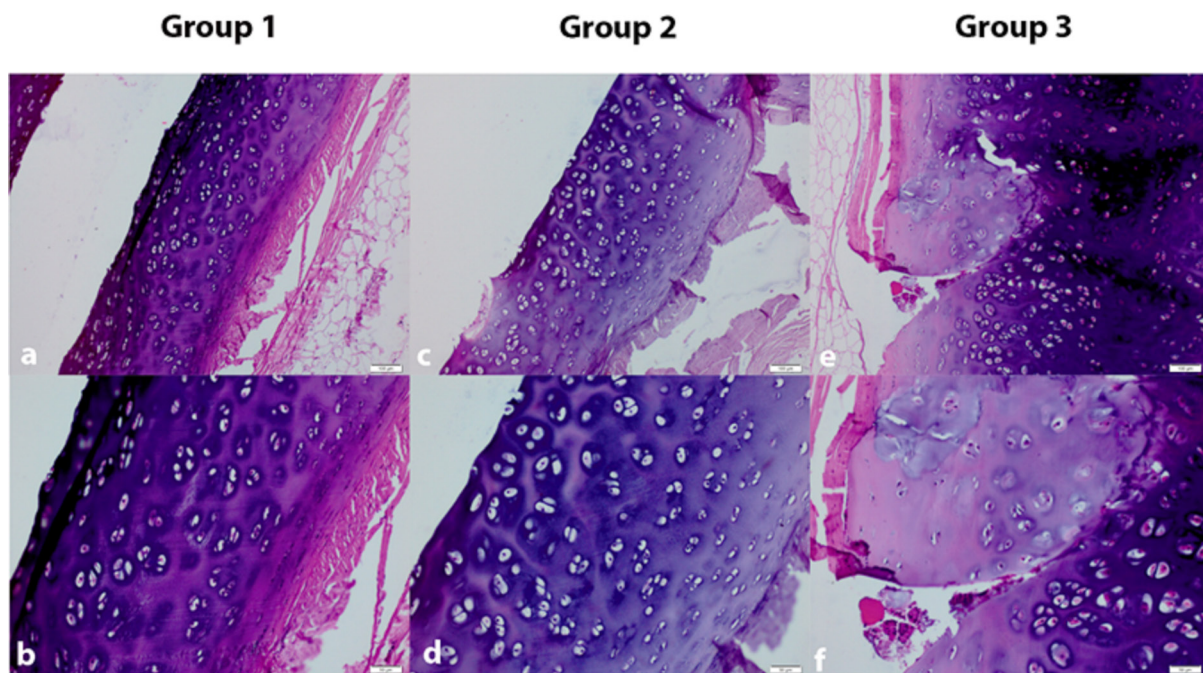
**Figure 1.** The tracheostomy procedure applied using two different techniques in sheep trachea. a: controlgroup b: Multiple dilatational tracheostomy c: Controlled rotating dilation technique

## Results

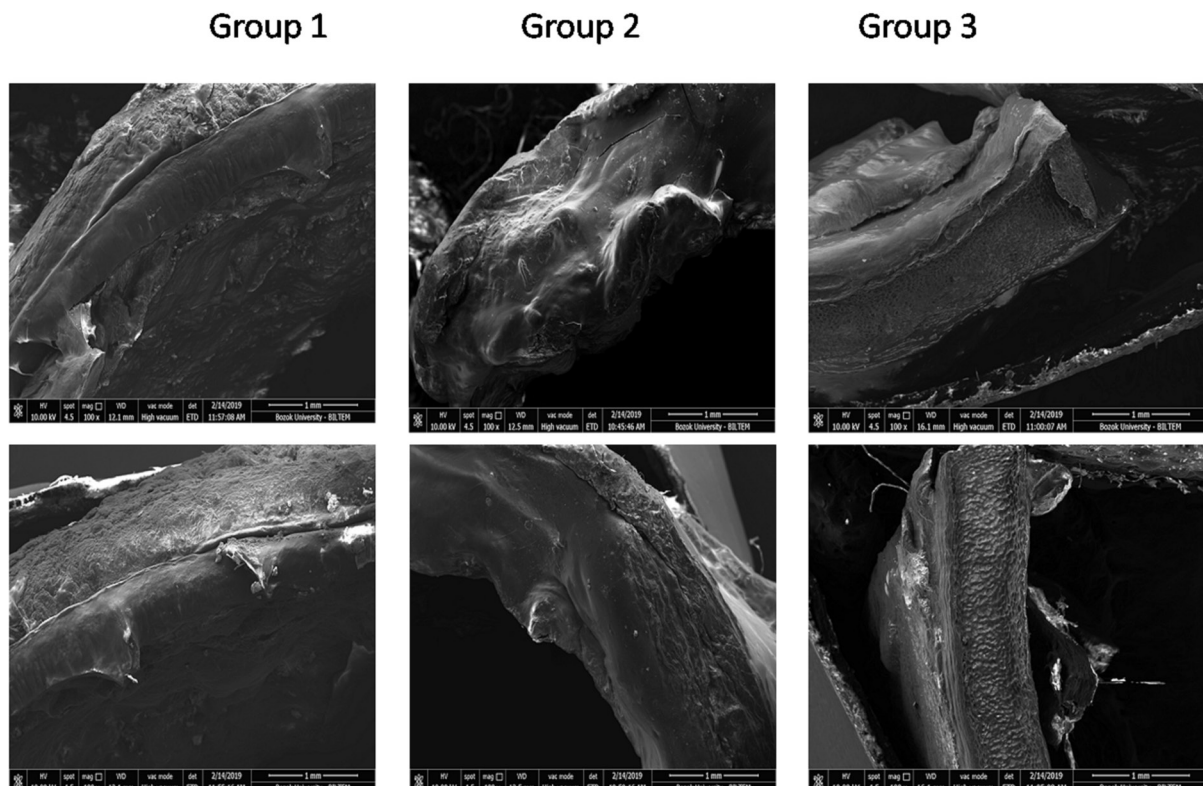
When the hematoxylin-eosin staining results of the sheep trachea slices were evaluated, cartilage integrity was observed to have been preserved in Groups 1 and 2. In Group 3, there was seen to be epithelial injury and disruption of the cartilage integrity (Figure

II).

In the evaluation of the electron microscopy images, the cartilage tissue integrity was clearly seen to be disrupted in Group III (Figure III). In Groups 1 and 2, tissue integrity was seen to have been preserved.



**Figure 2.** When the hematoxylin-eosin staining results of the sheep trachea slices were evaluated, cartilage integrity was observed to have been preserved in Groups 1 and 2. In Group 3, there was seen to be epithelial injury and disruption of the cartilage integrity. a, c, e images x10 magnification, bar=100µm, d, f images x20 magnification, bar 50µm



**Figure 3.** In the evaluation of the electron microscopy images, tissue integrity was seen to have been preserved in Groups 1 and 2, while in Group 3, there was seen to be both epithelial damage and disrupted cartilage integrity Discussion

There are many studies that have compared PT techniques with each other or with surgical tracheostomy. The incidence of PT complications has been reported as 1-10% [7]. Most of these complications are related to the technique and procedure, and as such are preventable. Complications can be examined under two headings of early and late. Early period complications include hemorrhagia, iatrogenic airway trauma, unwanted decannulation, subcutaneous emphysema, pneumothorax, hemothorax, stoma infection, difficulty in cannula placement, incorrect positioning, hypoxia, loss of airway control and associated early death. Late complications include the development of granulation tissue, trachea stenosis, tracheomalacia, trachea-innominate artery fistula, trachea-oesophageal fistula, pneumonia and aspiration [8].

PT is widely used in intensive care units around the world. The most preferred percutaneous dilatational tracheostomy techniques are as follows: multiple dilator, single dilator, forceps dilator, and twist dilator. The techniques differ in how the anterior tracheal wall is dilated. In a sequential dilatational tracheostomy, the wall is dilated with sequentially larger lubricated dilators over the guidewire. In CRDT the wall is dilated with a single-step, screw-type dilator.

A previous study has examined the pathological effects of the sequential dilator tracheostomy and dilation forceps tracheostomy methods in respect of acute trachea damage in sheep trachea. The results of that study showed that dilation forceps tracheostomy produced a larger stoma than sequential dilator tracheostomy in live anesthetized sheep, with dilation forceps tracheostomy showing a tendency towards larger anterior mucosal tears and a higher incidence of abnormal stoma shapes than sequential dilator tracheostomy. It was reported that mucosal injury was caused by percutaneous tracheostomy and it was suggested that this had a role in tracheal stenosis [9]. Unlike that study, electron microscopy was used in the current study to be able to evaluate tissue damage in detail. The results were similar to those of the previous study in that tissue integrity was seen to have been preserved in the group applied with the PDT method.

Many studies in literature have reported PT complications. However, the effect of tracheostomy application methods on complications associated with tissue damage and which develop in the late period have not been able to be compared as they cannot be examined taking human tissue. Of these complications, tracheal rupture which develops early and tracheal stenosis, which is seen in the late period, are important. Tracheal stenosis is generally at the stomal or suprastomal level [10] and is often accompanied by stomal granulation. Clinically significant tracheal stenosis has been reported to be seen in 3-12% of patients [11]. In a study which evaluated 100 patients applied with PCT, stenosis was determined at the rate of 11-25% in 21% of asymptomatic patients, and at the rate of 26-50% in 8% of symptomatic patients [12]. In another study of 200 patients which investigated the incidence of laryngo-tracheal stenosis, the probable cause was reported to be mucosal and submucosal ulceration [11].

In an article that presented two cases where the Griggs single forceps dilatation technique was used and tracheal rupture developed, it was reported that tracheal rupture can be caused during PT, both with increased force in patients with normal trachea and with minimal force in patients with flaccid trachea and

the quantification of force did not seem feasible.

In the current study, both techniques were applied by an experienced anaesthetist. Although rupture was not seen, injury caused by the PT method suggests that the application of the method by inexperienced individuals is higher risk in respect of rupture.

The Ciaglia and Percutwist techniques were compared in a prospective study and it was demonstrated that the Percutwist took longer to insert and had relatively more complications, mainly posterior wall erosions. Although the Percutwist technique may represent an alternative to the more established Ciaglia Blue Rhino technique, the Ciaglia technique, which is a safe and rapidly performed procedure for bedside tracheotomy, was reported to be the procedure of choice [13].

No posterior wall damage was seen in the current study. This was thought to be due to the procedure having been applied by an experienced physician by direct visualisation of the sheep trachea. The Ciaglia technique has been reported to be safer and this was supported by the current experimental study as tissue integrity was not disrupted with this technique.

A significant limitation of the current study was that it was conducted on animals obtained from the slaughterhouse. As the aim of the study was only to evaluate the mechanical damage on cartilage tissue, it was not wished to cause any harm to live animals. The trachea samples were obtained at the same time allowing the experiments to be conducted at the same time.

## Conclusion

In conclusion, percutaneous tracheostomy techniques may cause various complications in the acute and late periods. Preservation of tissue integrity is extremely important in the reduction of these complications. The results of this study showed that the MDT method may be superior to the CRDT method to maintain tissue integrity.

## Conflict of interest

*The authors declare that there are no conflicts of interest.*

## Financial Disclosure

*All authors declare no financial support.*

## Ethical approval

*Consent of ethics was approved by the local ethics committee.*

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