CASE SERIES

A Case Series: Overcoming Challenges of Delayed Intervention in Comminuted Laryngeal Fractures Using Adaptation Miniplates

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ABSTRACT

Introduction: Laryngeal trauma presents significant challenges in emergency medicine, often resulting from motor vehicle accidents. This study delves into the management of comminuted laryngeal fractures resulting from such accidents, utilizing the Schaefer-Fuhrman classification and the Legacy Emanuel Hospital and Health Center (LEHHC) Laryngeal Injury Classification for diagnosis and treatment guidance. **Case series:** Through the examination of three cases of comminuted laryngeal fracture, we have showcased the feasibility and efficacy of open reduction and fixation utilizing adaptive miniplates. The first and second cases involved comminuted fracture of thyroid cartilage which had delayed tracheostomy and fixation and adaptation of miniplates at day 16. The third case presented with comminuted and depressed thyroid and hyoid fracture which had delayed tracheostomy and fixation and adaptation of miniplates at day 6. All cases were decannulated eventually. **Conclusion:** Recommended for both stable and unstable thyroid fractures, these methods enable stabilization and bridging of any small cartilage losses incurred during the injury and subsequent repair process. Despite challenges such as delayed fracture stabilization due to the necessity of airway expertise, the positive outcomes observed in our cases underscore the potential for successful management even in complex scenarios.
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Keywords: Laryngeal trauma, Laryngeal injuries, Mini plates, Open reduction, Laryngeal fracture

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INTRODUCTION

Laryngeal traumas, whether blunt or penetrating, may result from motor vehicle accidents, assaults, "clothesline" incidents, or sport injuries.(1) The Schaefer-Fuhrman classification and the Legacy Emanuel Hospital and Health Center (LEHHC) Laryngeal Injury Classification are valuable tools for assessing and managing laryngeal trauma. (2-4) Utilizing standardized classification systems enhances patient care by providing a structured approach to diagnosis and treatment planning. Three cases of comminuted laryngeal trauma and treatment are discussed. The treatment approach involved laryngeal repair and reconstruction using adaptation mini plates and the two-point fixation method, following recommendations by Pou and Schaefer.(5) The use of adaptation mini plates for open reduction and fixation is described as a feasible and effective method for repairing laryngeal framework fractures. Although early intervention is recommended, all cases presented here experienced longer intervals between the incident and definitive management while awaiting airway expertise. Nevertheless, these cases also highlight positive outcomes in severely comminuted fractures, despite delayed fracture stabilization and repair.

CASE SERIES

Three cases of comminuted laryngeal fractures are presented and summarized in Table I. Cases were classified using the Schaefer-Fuhrman Classification

based on clinical presentations and Computer Tomography (CT) scans of the neck. There was a delay in laryngoscopy examination in the first case as he was intubated under emergency setting and extubated after 5 days. A low tracheostomy was performed in all cases in the same setting, just prior to fracture repair. A separate horizontal incision, approximately 1.5 cm above the tracheostoma, was made for neck exploration and laryngeal framework fracture repair. Comminuted fracture pieces were stitched together using prolene 4/0 to restore the shape of the thyroid cartilage. Two adaptation miniplates were inserted with 1.5 x 6mm screws to stabilize the fractured pieces.

Table I: Summary of cases. (n/a: not available, GCS – Glascow Coma Scale, CT- Computer Tomography)

Case	Age	Gender	Comorbidity	Mechanism of Injury	Presentation and assessment	CT Scan	Schaeffer Fuhrman Class	Intervention	Outcome
1	55	Male	none	Motor vehicle accident (mechanism unknown)	Orofacial bleed, deformed mandible, low GCS Laryngoscopy: left arytenoid displacement and left vocal fold immobility	Multiple maxillary and mandibular fractures, comminuted fracture of thyroid, fracture of hyoid	IV	Intubated under emergency (5 days) **Delayed Tracheostomy** and fixation with adaptation miniplates at **Day 16** (Figure 1 a and 1b)	Decannulated after 14 days, good voice and airway
2	49	Male	Diabetes Mellitus, Choledocolithiasis	Motor vehicle accident (Motorbike vs car)	Hoarseness, dysphagia, neck swelling, subcutaneous emphysema. Laryngoscopy: distorted laryngeal inlet, left vocal fold palsy and left arytenoid anterior dislocation	Comminuted thyroid fracture with severe narrowing of upper airway	IV	Not intubated due to adequate airway **Delayed Tracheostomy** and fixation with adaptation miniplates at **Day 16** (Figure 2 a and 2b)	Decannulated after 19 days, compensated vocal fold palsy
3	38	Male	None	Motor vehicle accident (back seat passenger of van, thrown and hit front head rest)	Hoarseness, odynophagia and dysphagia. Laryngoscopy: left vocal fold hematoma but with preserved mobility	Comminuted and depressed thyroid Fracture Hyoid fracture	IV	Not intubated due to adequate airway **Delayed tracheostomy** and fixation with adaptation miniplates at **Day 6** (Figure 3a and 3b)	Decannulated after 14 days, good voice and airway

Patients were administered Intravenous (IV) Dexamethasone 8mg, 8 hourly for three days to reduce laryngeal edema, and proton pump inhibitors (Pantoprazole 40mg, 12 hourly) to prevent adverse effects of reflux until decannulation. They were discharged with a tracheostomy tube and scheduled for weekly reviews for symptoms and laryngoscopy assessments. Decannulation was performed when laryngeal edema subsided, and there was no risk of upper airway emergency.

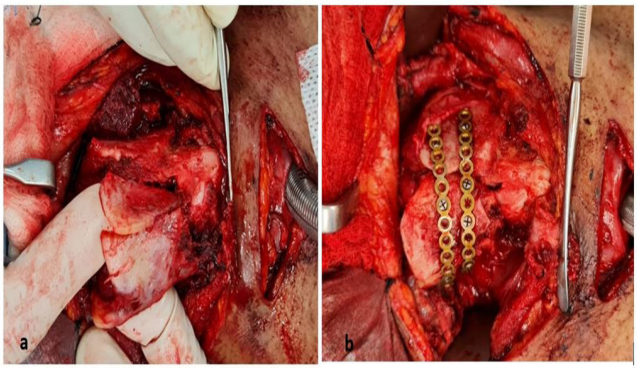

Figure 1: a) Comminuted fracture of the thyroid cartilage. b) Stabilization of fracture with adaptation miniplates.

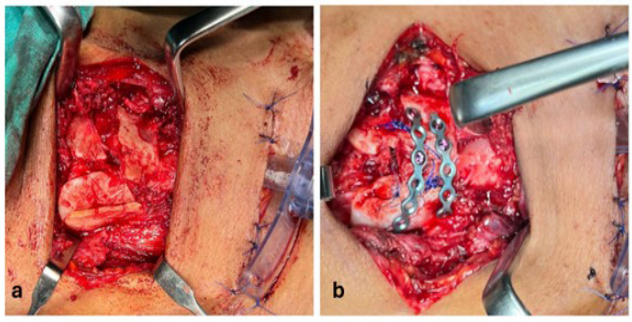

Figure 2: a) Comminuted fracture of thyroid cartilage, separate incision for tracheostomy is seen. 2b) Repair with prolene and adaptive miniplates

DISCUSSION

The cornerstone of laryngeal trauma management lies in understanding the mechanism of injury, encompassing factors such as trajectory, projectile nature, and the temporal evolution of events. Neck manipulation should be delayed until cervical spine injury is ruled out. Flexible laryngoscopy may be performed in a stable patient to assess the airway patency, vocal fold mobility, and the integrity of the pharynx and larynx.

Thin 1-2mm CT Scan slices are recommended for thorough visualization of fracture lines. Ossification in the thyroid cartilage begins after the age of 20. The hyoid bone is the only structure in the larynx that ossifies below the age of 20.(6) In cases involving young individuals with cartilage that has not ossified, or those with poorly ossified cartilage, CT might fail to detect laryngeal fractures and cartilage avulsions; thus, MRI may be used.(7)

The Schaefer-Fuhrman Classifications, based on clinical presentation and imaging findings, allow healthcare professionals to categorize injuries, providing insights into their nature and severity.(2,3) The LEHHC Laryngeal Injury Classification proposed by Verschueren et al. incorporates not only the clinical presentation and Schaefer's classification but also aspects related to management.(4) Therefore, it likely serves as a comprehensive framework for assessing laryngeal injuries, considering various factors such as clinical symptoms, imaging findings, and treatment approaches. This classification may provide a more nuanced understanding of laryngeal trauma, guiding clinicians in making informed decisions regarding patient care and management strategies.

Table II: Schaefer–Fuhrman classification.[3,4]

Group I	Minor endolaryngeal hematoma or lacerations Minimal edema No detectable fracture No airway compromised/ minimal airway symptoms
Group II	Demonstrable edema or hematomas and Minor mucosal disruption without exposed cartilage Non-displaced fracture Varying degree of airway compromise
Group III	Massive edema, large mucosal lacerations and exposed cartilages Displaced fractures Vocal Fold Immobility Significant Airway Compromise
Group IV	Same as group III but more severe with: Severe mucosal disruptions Disruption anterior larynx Unstable fractures /Two or more fracture lines Significant Airway Compromise
Group V	Complete Laryngotracheal Separation Catastrophic airway obstruction

Table III: The LEHHC Laryngeal Injury Classification[5]

	Clinical Presentation	Diagnostic findings	Management
Stage 1	Minor airway symptoms +/- voice changes	Minor hematomas Small Lacerations No detectable fractures	Observation Humidified Air Head of bed elevation
Stage 2*	Airway compromise Voice changes +/- Subcutaneous emphysema	Edema/hematoma Nondisplaced Fracture Minor mucosal disruption No cartilage exposure	Direct Laryngoscopy +/- open reduction and internal fixation (ORIF)
Stage 3*	Airway compromise Palpable laryngeal fracture Subcutaneous emphysema Voice changes	Massive edema Mucosal tears Class 2 Exposed cartilage Vocal fold immobility	Direct laryngoscopy Exploration/ ORIF
Stage 4*	Airway compromise Palpable laryngeal fracture Subcutaneous emphysema Voice changes	Massive edema Mucosal tears Multiple displaced fractures Skeletal instability Exposed cartilage Vocal fold immobility	Direct laryngoscopy Exploration /ORIF Consider stent

* Stage 2 to 4 receive immediate, "awake" tracheostomy if airway is not already secured in the field.

All patients suspected of laryngeal trauma should be admitted for at least 24-48 hours. In cases with no imminent airway obstruction, conservative management may be prescribed during the observation period. Flexible laryngoscopy should be repeated after 24 hours to assess laryngeal patency. Steroids may be administered to prevent the need for intubation or tracheotomy, facilitate extubation and reduce synechia formation by minimizing swelling and the associated contact between lacerated mucosal surfaces.(8) Proton pump inhibitors are prescribed for all patients, while prophylactic broad-spectrum antibiotics are administered if the laryngeal mucosa is compromised.(9)

The preferred method to secure the airway is tracheostomy under local anesthesia.(10) Oral intubation

is not contraindicated; however, there is a risk of further disruption of the endolaryngeal structures, creation of a false tract, or laryngotracheal separation. Prior to intubation, the larynx and trachea must be clearly intact and in continuity; the airway should be visible for direct inspection by endoscopy in the emergency department or operating room, and intubation should be performed by a highly experienced physician.(11) However, in cases of impending upper airway obstruction requiring an emergency airway, performing a tracheostomy under local anesthesia is the treatment of choice. A low tracheostomy is done below the usual site in thyroid cartilage fracture repair for these reasons which include to prevent disturbing the fracture area near the normal tracheostomy site, to reduce the risk of further damage to important laryngeal structures and to securing the airway by ensuring a safe airway while allowing the fracture to heal properly. It also helps prevent issues like infections or scarring near the repair site and facilitate smooth removal of the tracheostomy tube once healing is complete.

Patients with laryngeal framework fracture requires neck exploration, repair of mucosal injuries, open reduction and internal fixation with plating depending on the severity of injury. Fractures can be stabilized with wires, sutures, or mini plates. Implementing two-point fixation on each side of the fracture line, affecting the thyroid ala enables optimal fragment alignment and stability and potentially diminishes the necessity for laryngeal stents.(5,11) The adaptive miniplate, being pre-shaped or flexible, is contoured to fit the natural structure, allowing screws to secure the plate at two points, holding the fragments in place. This method ensures proper alignment and stability while minimizing the need for extensive contouring or manipulation. The most challenging aspect we faced was dealing with the second case, where the comminuted fractures consisted of multiple tiny pieces, and the cartilage was very friable. The small fragments of the thyroid cartilage had to be sutured together like a 'jigsaw puzzle' using Prolene 4/0 to restore the shape before stabilizing them with two adaptation miniplates. Other methods that can be used prior to plating may include mash overlay by thin titanium or absorbable mesh, fibrin glue or cartilage grafting to reconstruct the damaged thyroid cartilage and stabilize the area.

Delays in surgical intervention may also result in fracture dislocations healing and becoming fibrosed in abnormal positions, making it more challenging to reposition them before miniplate implantation, as was evident in both case one and case two.

Adaptation mini plates as used in our series instead of normal miniplates as it permit micro motion at the fracture line and facilitate healing through the deposition of bone or cartilage and the formation of a callus.(5) Adaptive miniplates also save fitting time, reduce the risk of poor contouring, and offer a better fit, especially in complex or curved areas, allowing for faster and more accurate stabilization. Normal miniplates are rigid and come in standard shapes, requiring manual bending to fit the bone.

While titanium plates are commonly used for their strength, ease of handling, and dimensional stability, they are limited by issues such as thermal sensitivity and stress-induced osteopenia due to retained metallic device. In contrast, bio-resorbable miniplates offer a promising alternative due to their seamless tissue integration. However, they present challenges such as inflammation, rapid strength decline, increased refracture rates, and lower stiffness compared to metal implants.(12)

The use of stents is debatable due to the balance between endolaryngeal support and the risk of further mucosal damage. Stents are primarily used for significant framework comminution or to prevent anterior commissure webbing in bilateral vocal fold epithelial loss.(9) Commercial endolaryngeal stents or custom stents from a Montgomery T-tube are used. In severe cases, a skin graft is placed on the stent. The stent is removed after 10–14 days.

CONCLUSION

Through meticulous surgical intervention utilizing adaptation mini plates and the two-point fixation method, we demonstrated the feasibility and effectiveness of open reduction and fixation in repairing laryngeal framework fractures. While challenges such as delayed fracture stabilization were encountered, the positive outcomes observed in our cases underscore the potential for successful management even in complex scenarios. In essence, our findings contribute to the body of knowledge surrounding laryngeal trauma management, providing valuable insights into effective treatment strategies and reaffirming the importance of evidence-based practice in optimizing patient outcomes.

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