A study was done on patients visiting the outpatient ear, nose, and throat (ENT) department of a tertiary-care hospital in north India between August 2017 and April 2019, with complaints of cough, throat pain, breathing/swallowing difficulty, voice change, sputum production, fever, and weight loss. The patients were evaluated by a clinical examination, followed by throat endoscopy, blood investigations, radiological examination (X-ray/CT scan of neck and thorax or both), sputum microscopy/culture, and Mantoux test. A histopathological examination of the tissue sample was done if required. The patients diagnosed with TB were included in the study. The patients with a past history of a surgical procedure in the throat or a history of trauma to the neck were excluded. The objectives of this study were to describe the intraoperative findings, the surgical technique used, the complications encountered, and the postoperative results. An informed consent was obtained from the patients, and an ethical clearance was obtained from the institutional ethics committee.

Case 1

The first case was a 21-year-old gentleman who presented with difficulty in breathing for the past 3 months which had aggravated...
in the last 3 days. He had been treated for pulmonary tuberculosis and the same had completed 3 months prior to presentation. A flexible laryngo-bronchoscopic examination revealed stenosis at the level of second/third tracheal ring with two very small openings, multiple webs, and secretions (Fig. 1). After an informed consent and planning with an anesthetist, the patient was taken up for surgical correction. The surgery was done under total intravenous anesthesia (TIVA) with propofol and fentanyl infusion, and laryngeal mask airway (LMA) of size 3 was used. Through the side channel of LMA, a flexible bronchoscope of size 3.5 mm was inserted. The bronchoscope’s working channel was used for delivering 400-micron diode laser fiber.

At the stenosed segment, radial incisions were given at 12-, 3-, and 9-o’clock position. Once a sufficient opening of the airway (around 4–5 mm) was obtained, a suspension laryngoscope was placed. Bougie dilatation with 7/9 mm was done (Fig. 2). Intermittent apnea technique (tube in–tube out technique) was employed during the procedure. After dilatation, 2 mg/mL of Mitomycin-C was applied, and injection triamcinolone acetonide was injected at the periphery of the stenosed site. The patient was discharged the next day with an advice of twice-daily nebulization with budesonide (0.5 mg), ipratropium (500 μg), and levosalbutamol (1.25 mg) for 3 weeks. He was followed regularly at an interval of 3 to 4 weeks in the outpatient department. Flexible scopy of the airway was done at each visit. After 4 months, the patient presented again with difficulty in breathing following an attack of upper respiratory infection. Flexible scopy showed circumferential tracheal stenosis covered with slough and secretions. The abovementioned procedure was repeated, and same follow-up was done. The patient again developed similar symptoms for the third time after 5 months. This time resection anastomosis (involving 4 tracheal rings) was done as a single-stage procedure, and the postoperative period was uneventful. The patient has been on regular follow-up and has remained asymptomatic till date.

Case 2
An 18-year-old boy presented with breathing difficulty for the past 3 months. He had developed change in voice and painful swallowing in the last 2 years. He was diagnosed to have laryngeal tuberculosis and had taken antitubercular treatment (ATT) for 9 months. Airway assessment was done with a flexible scope. There was an anterior glottis web and around 2-mm chink of airway. Emergency tracheostomy was performed followed by airway assessment under inhalational anesthesia. Posterior glottic stenosis with immobile cricoarytenoid joint was found (Fig. 3). CO₂ laser-assisted release of the web along with silicon keel placement and posterior cordotomy with partial arytenoidectomy (Fig. 4) was carried out. The laryngeal keel was removed after 3 weeks. The patient was gradually decannulated after 6 weeks of surgery. The patient is under follow-up after 2 years of surgery and remains asymptomatic.

Case 3
A 38-year-old female presented with change in voice of 4 months duration and noisy breathing during sleep. The patient had a past history of taking ATT for 9 months. Airway assessment was done with a flexible scope, and supraglottic and glottic narrowing having a lumen of around 6 mm was seen (Fig. 5). The stenosis was released using a CO₂ laser. A silicon sheet (1 mm thick) was placed as a stent (Fig. 6). The patient was followed up for 1 year; she had a satisfactory voice and no breathing difficulty.

Case 4
A 24-year-old male patient presented for a follow-up visit. He had a history of cough, fever, and loss of appetite 2 years back and was diagnosed with pulmonary tuberculosis. Following this, he was started on ATT. After 9 months of ATT, the patient had developed stridor, a tracheostomy was done, and eventually the patient had completed 12 months of ATT. During the current visit, he complained of a change in voice. A flexible endoscopy of the airway showed an anterior glottic web. He was taken up for laser-assisted release of the web and keel placement. Intraoperatively, the micro-laryngoscopy examination under TIVA showed anterior and posterior glottic stenosis (Fig. 7). The case was managed in a similar way as the previous mentioned patient (case 2).

Discussion
Upper airway involvement due to TB is either due to an air-borne spread or secondary due to implantation of the organism from infected sputum or hematogenous dissemination or infection via lymphatics. The pathogenesis of upper airway stenosis secondary to tuberculosis is same as endobronchial (lower airway) stenosis.
The pathological changes involve the mucosa, submucosa, and eventually the cartilage. The end result is fibrosis and stenosis of the airway. Endobronchial and tracheal TB affect the cartilage framework. There are various barriers in the form of muscle and fat planes in the upper airway which makes it less prone to involvement by the disease. TB bacilli affect both the surfaces of the vocal folds.
and there is hyperemia, ulcers, and granulation tissue formation. These lesions respond to ATT and might heal with the formation of a web and sometimes involvement of the crico-arytenoid joint.

Patients with primary laryngeal tuberculosis have a normal chest X-ray. Primary laryngeal involvement is seen in about 19% of TB cases. Laryngeal tuberculosis maybe categorized into four groups, namely, (a) whitish ulcerative lesions (40.9%), (b) nonspecific inflammatory lesions (27.3%), (c) polypoid lesions (22.7%), and (d) ulceroferangtive mass lesions (9.1%). In a recent publication on 15 cases of laryngeal tuberculosis by Marina Saldanha et al., two patients had primary laryngeal tuberculosis, and the others had an associated pulmonary involvement. Change in voice was the most common complaint, and ulcerative lesions were the most common finding. In our study, one of four cases had a primary laryngeal lesion (case 2).

Earlier studies have shown that TB mainly involves the posterior larynx. The recent studies point toward a predominance for vocal cords (50–70%) followed by false cords (40–50%), epiglottis, aryepiglottic folds, arytenoids, posterior commissure, and subglottis (10–15%). Lower airway can also be affected by tuberculosis. Tracheobronchial involvement was first described by Richard Morton, an English Physician in 1698. Lower airway involvement evolves from submucosal ulceration to necrosis with subsequent healing leading to a circumferential long segment stenosis. Cases 2 and 4 of our study presented with anterior and posterior glottis stenosis.

Case 1 presented with tracheal stenosis and fibrinous secretions. It recurred after the initial treatment due to perichondritis. Tracheobronchial stenosis due to TB is resistant to medical treatment and it recurred after the initial treatment due to perichondritis. Tracheo- posterior glottis stenosis. Cases 2 and 4 of our study presented with anterior and posterior glottis stenosis.

Predictors of persistent airway stenosis in patients with endobronchial TB were studied by Um et al. on 67 patients. Persistent bronchial stenosis occurred in 41.8% of the patients. Advanced age of the patient and long duration of complaints before the start of ATT are predictors of bronchial stenosis. Oral steroids do not reduce the depth of stenosis. Surgical intervention with limited use of laser, placement of stent, and application of anti-proliferative agents in reducing the stenosis. Surgical intervention with limited use of laser, placement of stent, and application of anti-proliferative agents in reducing the stenosis. Advanced age and long duration of complaints before the start of ATT increase the chance of development of airway stenosis. Oral steroids do not have much role in reducing the stenosis. Surgical intervention with limited use of laser, placement of stent, and application of anti-proliferative agents have a definite role to play in the management of airway stenosis. Sometimes multiple surgeries are required to achieve optimum results. Regular follow-up of the patients post-intervention is important to diagnose a recurrence and planning of subsequent management.

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