

Submental intubation: A journey over the last 25 years

Sabyasachi Das, Tara Pada Das, Pralay S. Ghosh

Department of Anaesthesiology, North Bengal Medical College, P.O.-Sushrutanagar, Dist- Darjeeling, West Bengal, India

Abstract

Airway management in patients with faciomaxillary injuries is challenging due to disruption of components of upper airway. The anesthesiologist has to share the airway with the surgeons. Oral and nasal routes for intubation are often not feasible. Most patients have associated nasal fractures, which precludes use of nasal route of intubation. Intermittent intraoperative dental occlusion is needed to check alignment of the fracture fragments, which contraindicates the use of orotracheal intubation. Tracheostomy in such situations is conventional and time-tested; however, it has life-threatening complications, it needs special postoperative care, lengthens hospital stay, and adds to expenses. Retromolar intubation may be an option, But the retromolar space may not be adequate in all adult patients. Submental intubation provides intraoperative airway control, avoids use of oral and nasal route, with minimal complications. Submental intubation allows intraoperative dental occlusion and is an acceptable option, especially when long-term postoperative ventilation is not planned. This technique has minimal complications and has better patients' and surgeons' acceptability. There have been several modifications of this technique with an expectation of an improved outcome. The limitations are longer time for preparation, inability to maintain long-term postoperative ventilation and unfamiliarity of the technique itself. The technique is an acceptable alternative to tracheostomy for the good per-operative airway access.

Key words: Adult, intubation, intratracheal methods, maxillofacial injuries/surgery, oral/methods, surgery

Introduction

Due to prominent anatomical location, maxillofacial injuries and fractures are nearly always associated with moderate-to-severe road traffic accidents (RTA). Mandible and zygomatic arch are commonest sites of fracture.^[1] About 21.8% of all the maxillofacial injuries need open reduction and internal fixation.^[2] Panfacial or maxillofacial injuries may lead to derangement of the architecture and disruption of different components (soft tissue, bony, and cartilaginous) of the upper airway, often with little external evidence of the deformity. In many such situations, neither oral nor nasal route for intubation is appropriate during the surgical repair. Recent

advancements in the discipline of oral and maxillofacial surgery and availability of new techniques and technologies have made rigid fixation with mini and microplate osteosynthesis possible in almost all facial fractures.

Delivery of anesthesia for maxillofacial surgeries is a challenge because the anesthesiologist has to share the upper airway field with the surgeon. Conventional orotracheal intubation is inappropriate as it interferes with the surgical access. Temporary intraoperative occlusion of teeth (intramaxillary and maxillomandibular fixation) is needed to check the alignment of the fracture fragments, making orotracheal intubation unsuitable. Most importantly, presence of altered airway anatomy and airway edema may compromise the airway. Options in airway management in these patients include tracheostomy, nasotracheal intubation, retromolar intubation, and submentotracheal intubation.

Nasotracheal intubation is not recommended in presence of panfacial fracture, cervical spine injury, skull base fracture with or without cerebrospinal fluid rhinorrhea, systemic coagulation disorders, distorted nasal anatomy and when nasal packing is indicated. Fiberoptic-guided nasotracheal intubation, though controversial, can be tried in selected patients.^[3] Nasotracheal intubation may be impossible as deformity or fracture of nasal bones, cribriform plate of ethmoid or naso-orbital ethmoid

Address for correspondence: Dr. Sabyasachi Das,
College Teachers' Qrt B-12, North Bengal Medical College,
P.O. - Sushrutanagar, Dist. - Darjeeling – 734 012, West Bengal, India.
E-mail: sabyasachi1968@gmail.com

Access this article online	
Quick Response Code:	Website: www.joacp.org
	DOI: 10.4103/0970-9185.98320

complex are often associated. Efficacy of topical anesthesia over traumatized and inflamed mucosa is uncertain. Moreover, even a small bleed in presence of altered anatomy may lead to complete loss of vision through a fiberscope and may lead to an emergent situation. Potential complications of nasotracheal intubation are mucosal dissection, injury to adenoids, meningitis, sepsis, sinusitis, epistaxis, dislodgement of bony fragments, and obstruction of the tube by the distorted airway anatomy or rarely intracranial intubation. In patients requiring simultaneous nasal or nasoorbital ethmoid reconstruction after the rigid fixation of mandible and/or maxilla, intraoperative switching over of the endotracheal tube (ETT) from nasal to oral route is required which may compromise the surgical field sterility and may increase the possibility of pulmonary aspiration. Possible difficulty in airway management, disruption of surgical repair, and obstruction to the operative field are additional limitations.^[4]

Elective short-term tracheostomy is the conventional and time-tested method for airway access in these patients. However, it may be associated with immediate and late complications. The procedure is difficult in obese patients, children, and patients with thyroid swelling.^[5] The incidence of immediate complications is 6–8% and they include hemorrhage, surgical emphysema, pneumothorax, pneumomediastinum, and recurrent laryngeal nerve palsy. The incidence of delayed complications is 60% and they include stomal and respiratory tract infections, blockage of the tube, dysphagia, difficulty with decannulation, tracheal stenosis, tracheoesophageal fistula, and suboptimal visible scar.^[6] Compared to tracheostomy, submental intubation is associated with lesser postoperative complications and requires minimal postoperative care resulting in shorter duration of hospitalization. This procedure can be carried out even in a set up with limited resources.^[7]

In 1983, Bonfils first documented the use of retromolar space for endotracheal intubation. Retromolar space is a space between the back of the last molar and anterior component of ascending ramus of the mandible, where it crosses the alveolar margin. The space may not be identical bilaterally due to the dissimilarities in development of the third molars and either of the side may provide space to rest the ETT.^[8] Patients with Le Fort II fracture, having both occlusive change and disruption of nasal architecture, are potential candidates for retromolar intubation. Facial trauma related trismus is not uncommon and even with complete dental occlusion this space can be used for suctioning the oropharynx or repositioning the ETT. Both Bonfils intubating fiberscope and flexible fiberscope have been used through this space in patients with difficult airway such as limited mouth opening, limited neck mobility, or cervical spine injury.^[9] Mertinez-Lage *et al.* reported retromolar route for endotracheal intubation in 39 patients requiring craniofacial and orthognathic surgeries, as a substitute for surgical airways

in 1998. With this simple, atraumatic, and rapid technique, intraoperative dental occlusion is possible and monitoring patency of the ETT is also not so difficult. Successful maxillofacial surgeries have been reported in good number of patients using this technique.^[10-12] Tooth loss is not infrequent in Le Fort II fractures and this gap can also be utilized to safely harbor the ETT secured on the maxillary side.

The primary requirement for a successful retromolar intubation is availability of adequate space in the retromolar area. The adequacy of retromolar space is judged by putting index finger of patient in the space and instructing him to occlude teeth slowly. After confirmation of adequate dental occlusion preoperatively and successful orotracheal intubation, the ETT is moved to the contralateral maxillary side of the retromolar space or missing tooth space and secured with silk sutures. This space is usually spacious enough to anchor an ETT of 7.0-mm ID in adult males. Suctioning of the oropharynx can be done through the opposite retromolar space. After the surgery, the retromolar intubation is dealt as a conventional orotracheal intubation. Monitoring peak airway pressure is of paramount importance, particularly during temporary dental occlusion. Retromolar intubation, a comparatively less invasive and time-efficient technique, may be an acceptable approach to the patient as it essentially serves the very same purpose of submental intubation. If the space is inadequate, the chance of accidental extubation is more. Retromolar space is usually adequate to accommodate the ETT in children. As a child grows, larger tube size is needed and this space tends to become smaller with age and with eruption of molars. There are large individual variations in the retromolar space in adults especially when the third molars are impacted or completely erupted.^[13]

If the retromolar space is not adequate, extraction of the third molar with a semilunar osteotomy in the area was suggested by Mertinez-Lage *et al.* to create enough space for resting the tube.^[14] The creation of retromolar space with an osteotomy was used to take almost 25 min in average.^[14] The technique was however more invasive, destructive, and time consuming and thus no longer practiced. Osteotomy-related permanent bone loss, just to create a space for temporary accommodation of an ETT, seems impractical. Retromolar intubation without osteotomy took 4 min 33 s in average from induction to ventilator switch on in 84 patients for retromolar intubation with tooth fixation^[11] compared to mean procedural time of 9.9 min in 746 patients for submental intubation.^[15] In a series of 15 patients, Malhotra found inadequate retromolar space in 3 patients who subsequently required submental intubation.^[16] Kruger *et al.* evaluated 2857 third molars of patients between 18 and 26 years of age and reported that nearly 42% third molars of maxillary side remained unerupted at 26 years of

age and that approximately one-third of fully erupted impacted third molars had been uprooted.^[17]

Preoperative submental intubation in craniofacial injuries was first proposed by a Spanish faciomaxillary surgeon, Francisco Hernandez Altemir in 1986.^[18] He proposed it as an alternative

to short-term elective tracheostomy, where both oral and nasal route for endotracheal intubation were not feasible. This technique is applicable where anatomy is likely to become normal after the surgery and long-term postoperative ventilation or protection of airway is not anticipated. Indications for submental intubation are maxillofacial injuries with associated

Table 1: Comparison of different techniques of airway access in complex maxillofacial injury

	Indication	Contraindication	Advantage	Disadvantage	Complication
Orotacheal	Commonest mode Skull base fracture Nasal pyramid fracture Multistage operation Emergency airway access	Upper airway obstruction Limited mouth opening	Conventional Convenient Nonsurgical Fastest	Limited surgical field Both surgeon and anesthetist compete for same anatomical space Intermaxillary fixation not possible Accidental extubation Fixation with adhesive tape difficult	Airway injury Laryngotracheal disruption Bleeding Infection
Nasotracheal	Limited mouth opening Faciomaxillary Surgeries not requiring repair of nasal pyramid Le fort I Surgeries requiring dental occlusion	Nasal abnormalities Possible skull base fracture with/without CSF rhinorrhoea Nasal mass Bleeding diathesis	Nonsurgical Allow dental occlusion Scope for visualization prior tube insertion No scar Good patient compliance	Inapplicable for nasal surgery	Nasal mucosa inflamed, infection, injury ± epistaxis Otitis media Sinusitis Disruption and distal dislodgement of fracture fragments
Tracheostomy	Emergency airway access Prolonged postoperative ventilation	Bleeding diathesis Local infection Anatomical abnormalities Difficult landmark	Long-term maintenance of airway Time-honored airway access	Surgical technique difficulty in children and in adult with goiter Needs special postoperative care Expensive and time consuming	Bleeding Postsurgical wound infection Cosmetically unacceptable scar Pneumothorax, pneumonia, surgical emphysema Tracheal stenosis/malacia
Submental	Elective cranio-facial, maxillary and nasal surgery Orthognathic and aesthetic face surgery Need for dental occlusion Adequate mouth opening with failed nasal intubation Patients having large pharyngeal flap ETT outside operating field	Local infection/injury Bleeding diathesis Laryngotracheal disruption Severe neurodeficit Prolonged need (>7 days)for airway maintenance and/or ventilation Gun-shot injury Inadequate mouth opening Tendency for keloid formation	Easy to perform Aesthetic scar Minimal distortion of soft tissue Sterility ensured Unimpeded surgical access Allows dental occlusion Motor and sensory damage unlikely Unlike tracheostomy specialized postoperative care not needed Less hospital stay and cost effective	Surgical Difficulty in suctioning Increased airway pressure Not permissible beyond 7 days Damage to ETT Scar formation Not feasible for repeated operation and probable reexploration	Bleeding Desaturation Accidental extubation Endobronchial intubation Chance of local infection/fistula/scar/mucocele
Retromolar	Faciomaxillary surgery	Limited retromolar space	Easy to perform Less time required Tube patency can be monitored Noninvasive, nontraumatic Simultaneous nasal surgery and dental occlusion possible	Limited retromolar space in adults Partially interferes with oral surgery	Long buccal nerve palsy Adjacent mucosal trauma Risk of inadequate occlusion Risk of unintended extubation

fractures of nasal bone and skull base^[19] or use of temporary intermaxillary fixation in patients where nasotracheal intubation is not possible. The scope of this technique has extended far beyond the realm of faciomaxillary surgeries and it has been successfully used in orthognathic surgeries and elective aesthetic face surgeries as there is minimal distortion of the nasolabial soft tissue. It is also used in surgeries where both nasal and oral passages are used by the surgeons (e.g., repair of postcancerum oris defects [Figure 1],^[20] oronasal fistula, selected cleft lip, and palate surgeries). Repair of congenital malformations, skull base surgery, multiple or complex facial osteotomies, transfacial oncologic procedures of the cranial base, and pediculated craniofacial surgeries are current indications for submental intubation.

The contraindications of submental intubation are patients' refusal, bleeding diathesis, laryngotracheal disruption, infection at the proposed site, gunshot injuries in the maxillofacial region,^[21] long-term airway maintenance,^[22] tumor ablation in maxillofacial region, and history of keloid formation.

A comparison of different techniques of airway access in complex maxillofacial injury is tabulated as Table 1.

Anatomical relevance

The submental area, situated just below the chin, is demarcated by the anterior bellies of digastric muscles of both sides, chin at the apex, body of the hyoid bone at the base with the mylohyoid muscles flooring it [Figures 2 and 3]. Usually superficial to mylohyoid, it contains a few anatomical structures like lymph nodes and thin vessels.^[23]

The submandibular region, just below the body and the ramus of the mandible, is bounded anteroinferiorly by the anterior belly of digastric, posteroinferiorly by the posterior belly of digastric muscles, and superiorly the inferior border of the mandible including the imaginary line projected to the mastoid process, being floored by mylohyoid and hyoglossus. Superficial to mylohyoid and hyoglossus there lie the submandibular gland, hypoglossal nerve, and a few arteries [Figure 4].^[23]



Figure 1: Postcancerum oris defect

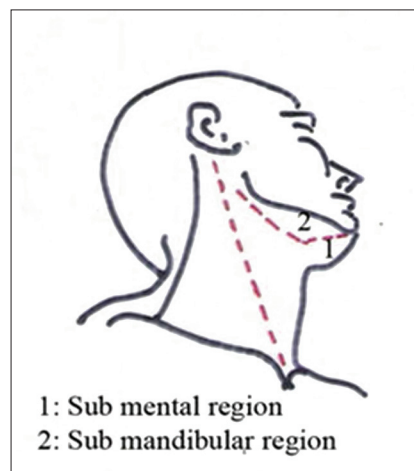


Figure 2: Surface anatomy of submental and submandibular region

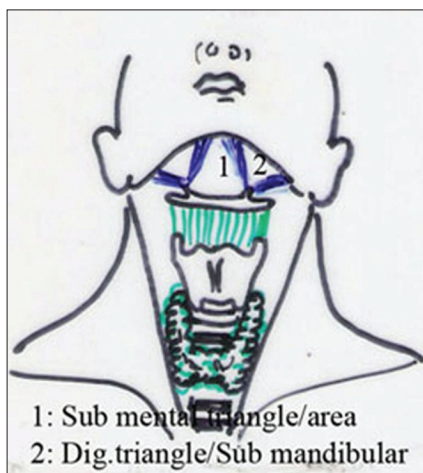


Figure 3: Submental and submandibular area after dissection

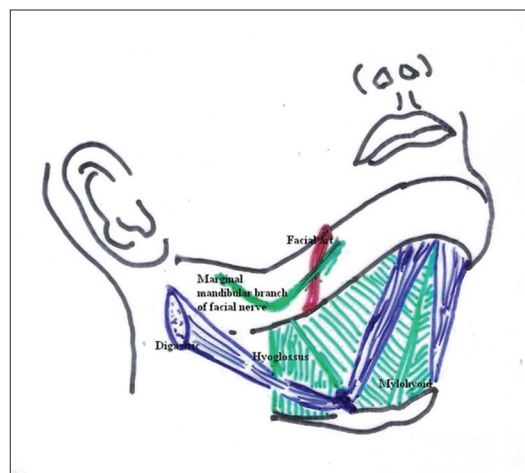


Figure 4: Submental and submandibular area after dissection

Both the routes (anterior-submandibular and posterior-submandibular, depending on the incision chosen) approach the floor of the mouth laterally to hyoglossus, an extrinsic quadrilateral muscle of tongue having origin at hyoid bone and insertion on the sides of the tongue. Laterally, it relates to the lingual nerve with submandibular ganglion coursing downwards and forwards, submandibular gland (deep part) with its duct hooked by the lingual nerve, and the hypoglossal nerve coursing upwards and forwards to supply the tongue.^[24] In the posterior part of the submandibular area, not only the lingual and hypoglossal nerves are wide apart but also the submandibular gland exists instead of its duct. In the anterior part, those two nerves get closely approximated in convergence manner with sharing some fibers of hypoglossal and lingual nerve.^[24,25]

In the anterior submandibular approach, there is immense chance of facing the two main nerves of tongue and the submandibular duct along with the sublingual gland is in close proximity to one another, which can get damaged unintentionally. If we approach at a posterior plane at the level of third molar (posterior submandibular approach), there is less chance of such damage. Only possible hindrance could be by the submandibular gland itself, which can be easily retracted without any anatomical or functional damage [Figure 5].

The submental intubation

The conventional submental intubation technique essentially involves creation of an orocutaneous tunnel and diverting the proximal end of the armoured ETT through anterior floor of the mouth.

Appropriate broad spectrum antibiotic, preferably amoxicillin and clavulanic acid, is given intravenously 1 h prior to the procedure. In patients allergic to penicillin, usually first-generation cephalosporin is prescribed. Antisialogogue and aspiration prophylaxis should be considered. Tight seal of the appropriate-sized flexometallic ETTs is made easily detachable from the universal connector. Measures to tackle any emergent situation (e.g., cricothyrotomy and transtracheal jet ventilation) are kept ready, especially for those patients who cannot withstand brief period of cessation of ventilation. There are certain modifications of the classic technique that allow ventilation during tube transfer. Refinements such as double tube method or airway exchanger technique reduce the time between detachment of the circuit and reattachment. General anesthesia and orotracheal intubation with appropriate-sized armoured ETT are done in conventional way. Area around proposed site of incision is prepped with 10% povidone iodine solution and is draped with sterile dressings. After local infiltration of skin and soft tissue of the proposed site with 2% lignocaine with adrenaline, a skin incision is made

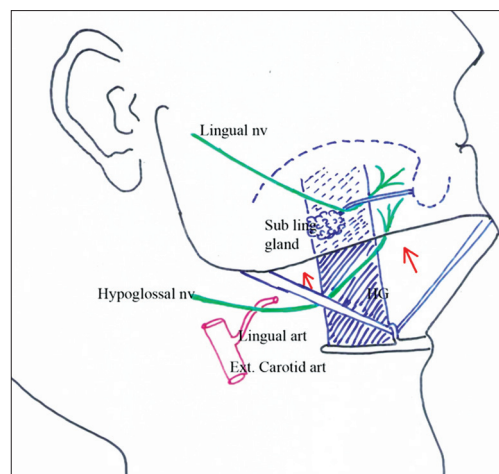


Figure 5: Intubations through anterior part of digastric triangle (right red arrow) may damage the closely approximated lingual nerve, hypoglossal nerve and sublingual duct, whereas in the retromolar space (left red arrow) there are lesser chances of damaging them as they are far apart.

in the right submental region parallel to the inferior border of the corresponding mandible [Figure 6].

Approximately 1.5 cm incision is good enough for easy passage of ETT up to 7.5 mm size and 2 cm incision is required for ETT of larger diameter. Right-sided incision is always advantageous as it permits better visualization of the intraoral part of the ETT by left handed laryngoscopy. However, selection of the side is usually done so as to avoid the site of injury and mandibular fracture. Blunt dissection is carried out with a medium-sized curved artery forceps or Kelly clamp along the lingual surface of the mandible through subcutaneous tissue, platysma, investing layer of deep cervical fascia, mylohyoid muscle in between the two heads of digastrics muscles to sublingual mucosa [Figure 7].

A paramedian oral incision is made over the tented mucosa created by the tip of the artery forceps. Tongue is retracted on the other side for better visualization. Adequate exposure of the oral cavity is maintained with a gag. The tunnel created is widened by separating two blades of the artery forceps. Use of two artery forceps facilitates exposure better than a single one. The patient is ventilated with 100% oxygen and 1% isoflurane for 5 min, before replacing the tube through the incision, to tolerate the period of ventilatory pause. After denitrogenation, breathing circuit is disconnected and universal connector is detached from the tube. The tip of the pilot balloon cuff is pulled through the submental incision first [Figure 8].

Then the tip of the artery forceps is again introduced through the incision to take out the distal end of the ETT in similar fashion and the ETT is placed in the sulcus between the tongue and the mandible in the floor of the mouth. While pulling, the intraoral



Figure 6: Incision made in the midline in submental region



Figure 7: Blunt dissection using artery forceps



Figure 8: Pilot balloon exteriorized through the orocutaneous tunnel



Figure 9: Endotracheal tube rerouted through submental space and fixed to the skin

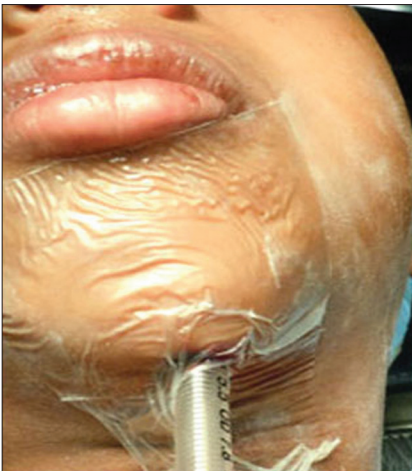


Figure 10: Transparent dressing applied to observe tube dislodgement



Figure 11: Awake patient tolerating the tube well (permission obtained from the patient)

part of the flexometallic ETT is kept steady with a Magill's forceps or the index finger of an assistant. The connector is reattached and the ETT reconnected with the breathing circuit. The position of the tube is confirmed by direct laryngoscopy, chest auscultation, and capnography. The skin exit point of the

ETT is marked with permanent ink. The ETT is secured to the skin using stay suture with 2-0 heavy silk. Additional fixation by placing a tie suture between the ETT and the universal connector can be applied for further safety. Transparent adhesive dressing is

applied over the skin to avoid displacement while manipulating the mandible as well as to visualize the ink mark [Figures 9 and 10].

A throat pack is applied if necessary. Capnography has specific importance for alerting the anesthesiologist about tube compression, accidental extubation, or endobronchial intubation with jaw movement during surgery. Airway pressure is monitored peroperatively to detect inadvertent tube compression or deviation. If regular tube is used, assisted manual ventilation during surgery can pick up early evidence of tube compression or kinking. At the end of the surgery, the stay sutures are removed, followed by throat pack. Tracheal extubation is done in the operation theatre or in the postoperative recovery room through the submental route, when the standard criteria of extubation are fulfilled and patient is awake and maintaining airway reflexes. Guedel's airway may be used in cases of submental extubation. As airway and soft-tissue edema can compromise airway in the immediate postoperative period, all patients should be dealt as difficult extubation cases. In situation when there is need for long-term airway maintenance or ventilatory support, the submentotracheal intubation is converted back to orotracheal intubation by pulling the proximal end of the ETT and pilot balloon through the incision. After local infiltration of the wound with 2% lignocaine and adrenaline, the platysma is closed with an absorbable suture and skin closed with monofilament suture. The skin suture applied should be not too tight to allow drainage of tissue fluid. The mucosal wound is left to heal by secondary intention. During the postoperative period, good hydration status is maintained which is of paramount importance regarding wound healing. Care of the intraoral wound is done by maintenance of oral hygiene using 0.12% chlorhexidine mouth wash six hourly. The broad spectrum antibiotics are continued postoperatively.^[26] In case of wound infection or suppuration, cutting one or two stitches usually resolves the complication. Skin stitches are removed after 5–7 days. As some of the complications of the submental intubation may appear late, the patients are followed up till discharge, and after 1, 3, and 6 months postoperatively.

Modifications over the last 25 years

Since first-published report of Altemir, several modifications of submental/submandibular endotracheal intubation have been tried with an expectation of improved outcome. All modifications of submentotracheal intubations are essentially transmylohyoid. Gadre and Waknis^[27] considered transmylohyoid as more appropriate terminology, as in this technique the ETT can pass through the mylohyoid muscle anywhere between the first mandibular molars of either side anterior to the masseter muscle, instead of limiting to the submental triangle. In patients with compound comminuted fracture of symphysis and parasymphysis, the conventional

submental technique may result in significant stripping of lingual periosteum that can jeopardize blood supply. Most authors are of the opinion that subperiosteal tube placement, as proposed by Altemir in his first report, is not essential.^[14,28] The placement of ETT in the anterior part of the submandibular region and “submento-submandibular” intubation seem more appropriate nomenclatures.^[29] In strict midline approach, (both mylohyoid muscles meet in the midline in an avascular plane) the chance of bleeding is less.^[30] Moreover, transfer of ETT is easier as structures are less cramped. Use of two ETT (one antegrade and the other retrograde) is claimed to be superior because there is less chance of hypoxia if there is difficulty in retrieval and no need of detaching the connector.^[28] After conventional orotracheal intubation with a regular ETT, another reinforced ETT is introduced through the submental incision from exterior to the oral cavity and negotiated in the oropharynx with a McGill forceps. The regular orotracheal tube is then exchanged with the submentally introduced armoured tube. This idea is supported by other authors as well.^[31,32] Hanamoto *et al.* used sterile polypropylene cylinder of 10-ml syringe, through the submental incision into the oral cavity. The distal end of the orotracheal tube was connected with the proximal end of the second tube passed through the submental tunnel. Ventilation was possible during re-routing the orotracheal tube through the submental path.^[33]

One serious drawback of retrograde technique is that it may result in introduction of infection to lower airways. Risk of sepsis can be due to the contaminated pilot balloon passing through the incision wound during extubation. Cutting the end of the ETT and replacement with another universal connector has also been advocated.^[21] Conversion of the orotracheal to submento-tracheal intubation can be done faster with use of a tube exchanger.^[34] Drolet *et al.* suggested the use of a tube exchanger to exchange a damaged ETT through the submental route. It facilitates exchanging the tube without loss of airway in difficult airway situations even with a steeper angle than oral or nasal route. During the procedure the patient can be ventilated through the port into the airway exchanger minimizing the chances of desaturation. Injury to the pilot balloon while retrieving through the tunnel can be averted by inserting the deflated pilot balloon into the ETT.^[27] The ETT is further cleared of any blood or secretion after it is taken out.

“Rule of 2-2-2” – 2 cm long incision, 2 cm away from the midline, 2 cm medial and parallel to the mandibular margin has been suggested by Nyarady *et al.*^[35] Nylon guiding tube for exteriorizing the ETT has less chance of injury to the associated structures.^[35] Dilators of percutaneous dilatation sets can be used to create mucocutaneous fistula as an alternative to blunt dissection and are claimed to produce

minimal scar and minimal bleeding.^[36] A 100% silicon wire reinforced tube primarily intended for intubation through intubating laryngeal mask airway (ILMA) is a better option as it has an easily removable universal connector.^[37] A 1.5-cm skin incision, 1 in. below and 0.5 in. anterior to the angle of the mandible is found to be more advantageous as posterior placement of the tube assures unobstructed surgical field.^[4]

Mahmood and Lello^[38] performed submental intubation using preformed Sheridan tube. The preformed curvature helps in positioning of the tube as it conforms to the anatomy of the region. Lima *et al.*^[39] in their study utilized surgical glove finger to cover the proximal end of the ETT, which helped in preventing the entry of blood and soft tissue during its passage through orocutaneous tunnel. Similarly, Adeyemo *et al.*^[40] used nylon tube sac to cover the open end of the tube during transfer through the tunnel. The submental route has also been used for the LMA with reinforced tube in specific situations such as laryngotracheal disruption, voice professionals refusing endotracheal intubation, and patients with unstable cervical fractures posted for faciomaxillary surgery. However, movement of patient's head should be very gentle and great care is needed to prevent dislodgement of the LMA.^[41]

The use of Combitube SA (Tyco-Kendall, Mansfield, MA) through the wide submental incision or the external injury site makes provision for adequate dental occlusion, unimpeded surgical access, and ease of ventilation in severe maxillofacial injuries. Moreover, the inflated proximal balloon helps to allay pain and minimizes bleeding by spontaneous reduction of fracture fragments.^[42]

There are risks of accidental extubation and increased chance of aspiration. These problems are more in the pediatric population. Bleeding from the incision site usually responds to pressure. Compression and deviation of the tube result in increased airway pressure during surgical maneuver. There is difficulty in passing the tube through submental incision^[43] and chance of hypoxia if retrieval of tube and reestablishing connection is delayed. There is intraoperative difficulty in passing nasogastric tube.^[19] There are incidences of superficial infection, abscess, sepsis, damage to the lingual nerve, hypertrophic scar, orocutaneous fistula, and mucocele.^[44] Superficial infection of the submental incision site is documented as the most common complication, whereas airway compromise is stated to be most important potential complication. Fortunately, most of the reported superficial infections responded to local measures and minimal intervention like partial removal of stitches.^[45] Trauma to submandibular and sublingual gland and ducts and salivary fistula have also been described.^[18,46,47] Suctioning is difficult

through the tube and can be done after extension of the neck with well-lubricated suction catheter. The postoperative period may be complicated by airway edema, obstruction, hematoma, and reexploration. Yoon *et al.*^[48] reported of accidental detachment of a deflated pilot balloon while manipulating the balloon during converting the submental intubation back to orotracheal. It was managed by cutting a pilot balloon from a new ETT and by connecting it to the first tube by a 20G needle connector. Submento-tracheal intubation is generally better tolerated by the awake patient than orotracheal intubation [Figure 11]. Chance of biting the ETT by the patient with disruption of the surgical repair is always a threat in oral extubation.^[4]

Though adequate mouth opening is an essential part of conventional submental intubation, successful retrograde submental intubation (combination of retrograde intubation and submental intubation) is also reported in a patient with faciomaxillary trauma with restricted mouth opening due to bilateral temporomandibular joint dislocation.^[22] Adequate retromolar space is an essential prerequisite to introduce the suction catheter and necessary arrangements must be ready to cope with any emergency situation.

There is a trend of rising attention on this useful, but underutilized mode of airway access over the last 25 years. Nearly 90% of the publications on this topic have been reported in PubMed in the last decade. A brief summary of review of literature on the submental intubation in PubMed is tabulated as Table 2. A recent literature review comprising 842 patients and 41 articles cites the success rate of this technique as 100%^[15] with duration of the procedure varying between less than 4 min to 30 min. This study also reports of development of a hypertrophic scar in 3 patients out of 842 patients. As aesthetic acceptance of the scar is highly unpredictable, nasal route of airway access, if possible, is always a better choice. The utility of submental intubation is guarded in elective midfacial osteotomy, although there are reports of successful submental intubation in no less than 100 patients. Further research work in larger scale is needed to compare submental intubation with tracheostomy.

Conclusion

Submental intubation seems to be an attractive and adaptive option for intraoperative airway control in selected complex craniofacial injuries. This enjoys the advantages of both orotracheal and nasotracheal intubation at the same time. Though it demands some surgical skill, the technique is simple, rapid, and easy to learn. Better cosmesis, minimal complication and lesser expenses are added advantages. The overall increase in operating period by about 20 min is one of

Table 2: Brief summary of review of literature in PubMed over the last 25 years

Author	Year	Study design	Participants	Complications	Remarks
Altemir <i>et al.</i> ^[18]	1986	Case study	1	None	Maiden report. Nasal speculum used to facilitate passage of the tube through submental region
Gordon and Tolstunov ^[46]	1995	Case study	2	None	Nothing specific
Green and Moore ^[28]	1996	Case study	1	None	Two tubes. First tube oral, second tube submental. Substitution of oral tube with submental (Modification: allows use of endotracheal tube with nondetachable connector)
Manganello-souza and Tenorio-cabezas ^[49]	1998	Case study	10	Superficial wound infection (two)	Nothing specific
MacInnis and Baig ^[30]	1999	Case study	15	None	Average time required 6 min. Modification of technique: midline incision 2 cm posterior to Wharton's duct, with an idea of minimizing bleeding (damage to lingual artery).
Drolet <i>et al.</i> ^[34]	2000	Case study	1	None	Lubricated tube exchanger, avoids delay in exchanging damaged tube
Caron <i>et al.</i> ^[6]	2000	Retrospective analysis	25	Superficial submental wound infection in one case.	Average time required of few minutes.
Paetkau <i>et al.</i> ^[31]	2000	Letter to the editor	1	None	Nonreinforced ETT Time required less than 10 min
Altemir and Monterro ^[41]	2000	Case study (surgical technique)	3	None	Modification: LMA used instead of ETT
Mak and Ooi ^[32]	2002	Case study	1	None	Used in orthognathic surgery
Mahmood and Lello ^[38]	2002	Case series (surgical technique)	5	None	Modification of surgical technique: 1 cm midline incision between Wharton's duct and the reflection of lingual gingivae to decrease bleeding and to avoid injury to important structures.
Nwoku <i>et al.</i> ^[50]	2002	Case study (surgical technique)	10	None	Modification of surgical technique: 2 cm laterosubmental incision to avoid significant structure in floor of mouth
Amin <i>et al.</i> ^[37]	2002	Retrospective study	12	One right mainstem endobronchial intubation Venous bleeding in one case Inadvertent extubation in one case	Suggested use of capnography as an early warning of displacement Use of 0.12 % chlorhexidine mouthwash postoperatively
Ball <i>et al.</i> ^[51]	2003	Correspondence	Not mentioned	Not recorded	Modification: Flexible tracheal tube dedicated for ILMA. Connector can be removed easily and replaced.
Altemir <i>et al.</i> ^[42]	2003	Case study (surgical technique)	2	None	Modification: Combitube SA through submental route-allows dental occlusion, unimpeded surgical field, ease of ventilation, proximal balloon reduces pain, bleeding by spontaneous reduction of fracture fragments
Lim <i>et al.</i> ^[52]	2003	Case study (surgical technique)	1	Not reported	Modification: with an idea of minimizing ETT damage a blue cap of 33 Fr thoracic catheter is placed over the distal end of the tube including the pilot balloon and tube. Ease of tube transfer.
Biglioli <i>et al.</i> ^[14]	2003	Retrospective study	24	Superficial infection in one case	Average time reported 5 min
Meyer <i>et al.</i> ^[19]	2003	Case series	25	Hypertrophic scarring in one case Abscess formation in one case	Nothing specific
Yoon <i>et al.</i> ^[48]	2004	Case report	1	Pilot balloon accidentally detached	Managed by cutting pilot tube from new ETT, connected to first tube by needle connector
Nyarady <i>et al.</i> ^[53]	2004	Case series	8	None	Orthognathic surgery

Table 2: (Continued)

Author	Year	Study design	Participants	Complications	Remarks
Arya et al. ^[22]	2005	Case study (surgical technique)	1	None	Restricted mouth opening Pharyngeal loop used. Noninforced ETT
Kim et al. ^[54]	2005	Case series	4	None	Average time required 10 min
Kim et al. ^[55]	2005	Case study	2	None	Average time required 7 min Reinforced LMA used
Taglialatela et al. ^[29]	2006	Retrospective study	107	Superficial wound infection in 11 cases Orocutaneous fistula in 8 cases that resolved to conservative measures within 10 days Damage to ETT apparatus in 6 cases	Average time less than 10 min, used two tube technique, coined the term “submento-submandibular intubation”
Eipe N et al. ^[20]	2005	Case study	1	None	Post cancrum oris defect
Nyarady et al. ^[35]	2006	Case series (surgical technique)	13	None	Modification: Placement of sterile nylon guiding tube over the distal end of the tube with an idea of reducing tube damage. Orthognathic surgery Average time 4 min
Biswas et al. ^[36]	2006	Letter to editor	2	None	Modification: Percutaneous dilatational tracheostomy kit to facilitate transfer of tube through orocutaneous tunnel with an idea of minimized bleeding and tube damage
Caubi et al. ^[56]	2008	Retrospective study	13	ETT compression and increased airway pressure in one patient	Nonreinforced ETT Used Kelly forceps Average time required is less than 10 min Ventilation disconnection time 2 min Post-op. ventilation needed for two patients Platysma closed with 4-0 vicryl Skin closed with 5-0 nylon
Schutz and Hamed ^[57]	2008	Retrospective study	8	Damage to ETT apparatus	Nothing significant
Chandu et al. ^[58]	2008	Retrospective study	44	Superficial infection in two cases Mucocoele in one case Lingual nerve injury in one case dislodged ETT in 2 cases Damage to ETT in 1 case	Average time required 20 min
Babu et al. ^[59]	2008	Case study	1	None	Reported time 5 min
Sharma et al. ^[60]	2008	Case series	20	Partial extubation in one case Superficial wound infection in one case	Average time required 9 min
Elizar'eva et al. ^[61]	2008	Case series	17	None	Average time required 5–6 min
Langford ^[62]	2009	Case study	1	Pilot balloon entrapment	LMA used instead of ETT
Uma et al. ^[63]	2009	Case report	1	none	Nothing significant
Gadre and Waknis ^[27]	2010	Retrospective study	400	Orocutaneous fistula in two cases Tracheal tube damage in one case Keloid in 2 cases	Average time required 10 min Inserted deflated pilot balloon into ETT during its passage through the wound to prevent damage

Table 2: (Continued)

Author	Year	Study design	Participants	Complications	Remarks
Garg M and Rastogi ^[64]	2010	Case series	10	Superficial wound infection in one case	Average time reported 8 min Disconnection time 1.8 min Cuff not deflated during passage through tunnel Two patients required elective postoperative ventilation
Navaneetham et al. ^[65]	2011	Retrospective study	15	Partial obstruction of ETT in two cases	Average time required 10 min
Agarwal and Kang ^[66]	2011	Prospective study	25	Venous bleeding in one case Superficial wound infection in two cases	Average time 7.08 ± 0.81 min
Shetty et al. ^[67]	2011	Prospective study	10	None	Mean time 5.9 min (5–8 min)
Hanamoto et al. ^[33]	2011	Case report (surgical technique)	1	None	Modification: Patient had hypoplasia of nose. Two tubes were used- First orotracheal to establish breathing, followed by submental tube. Distal end of the first one was connected to proximal end of the later.
Jundt et al. ^[15]	2012	Retrospective study	842	Skin infection, damage to tube, fistula, right endobronchial intubation, accidental extubation, venous bleed, mucocele	Submental intubation successful in 100% cases

its limitations. There is still no consensus regarding superiority of one technique over another as a mode of securing airway in complex craniofacial injury repair. Paucity of published literature (case reports and case series) and quality of evidence limit definite recommendation on its use. Patient's ability to cooperate with the procedure, liaison between the surgeons and the anesthesiologists, experience of airway managers to deal with the situation, and benefits of single versus multiple surgical interventions are important considerations. Prolonged period of time is required for the adequate planning, preparation of the patient, personnel and procedure, which limits the utility of this technique in emergency situations.

References

- Venugopal MG, Singha R, Menon PS, Chattopadhyay PK, Roychowdhury SK. Fractures in the maxillofacial region: A four year retrospective study. *Medical Journal Armed Forces India* 2010;66:14-7.
- Chandra Shekar BR, Reddy CV. A five-year retrospective statistical analysis of maxillofacial injuries in patients admitted and treated at two hospitals of Mysore city. *Indian J Dent Res* 2008;19:304-8.
- Arrowsmith JE, Robertshaw HJ, Boyd JD. Nasotracheal intubation in the presence of frontobasal skull fracture. *Can J Anaesth* 1998;45:71-5.
- Anwer HM, Zeitoum IM, Shehata EA. Submandibular approach for tracheal intubation in patients with panfacial fractures. *Br J Anaesth* 2007;98:835-40.
- Durbin CG Jr. Early complications of tracheostomy. *Respir Care* 2005;50:511-5.
- Caron G, Paquin R, Lessard MR, Trepanier CA, Landry PE. Submental endotracheal intubation: An alternative to tracheotomy in patients with midfacial and panfacial fractures. *J Trauma Infect Crit Care* 2000;48:235-40.
- Kar C, Mukherjee S. Submental intubation: An alternative and cost-effective technique for complex maxillofacial surgeries. *J Maxillofac Oral Surg* 2010;9:266-9.
- Xue FS, He N, Liao X, Xu XZ, Liu JH. Further observations on retromolar fibreoptic orotracheal intubation in patients with severe trismus. *Can J Anaesth* 2011;58:868-9.
- Truong A, Truong DT. Retromolar fibreoptic orotracheal intubation in a patient with severe trismus undergoing nasal surgery. *Can J Anaesth* 2011;58:460-3.
- Dutta A, Kumar V, Saha SS, Sood J, Khazanchi RK. Retromolar tracheal tube positioning for patients undergoing faciomaxillary surgery. *Can J Anaesth* 2005;52:341.
- Lee SS, Huang SH, Wu SH, Sun IF, Chu KS, Lai CS, et al. A review of intraoperative airway management for midface facial bone fracture patients. *Ann Plast Surg* 2009;63:162-6.
- Rungta N. Technique of retromolar and submental intubation in facio-maxillary trauma patients. *Ind J Trauma Anaesth Crit Care* 2007;8:573-5.
- Arora S, Rattan V, Bharadwaj N. An evaluation of the retromolar space for oral tracheal tube placement for maxillofacial surgery in children. *Anesth Analg* 2006;103:1122-6.
- Biglioli F, Mortini P, Goisis M, Bardazzi A, Boari N. Submental orotracheal intubation: An alternative to tracheostomy in transfacial cranial base surgery. *Skull Base* 2003;13:189-95.
- Jundt JS, Cattano D, Hagberg CA, Wilson JW. Submental intubation: A literature review. *Int J Oral Maxillofac Surg* 2012;41:46-54.
- Malhotra N. Retromolar intubation-a simple alternative to submental intubation. *Anaesthesia* 2006;61:515-6.
- Kruger E, Thomson WM, Konthasinghe P. Third molar outcomes from age 18 to 26: Findings from a population-based New Zealand longitudinal study. *Oral Surg Oral Med Pathol Oral Radiol Endod*

- 2001;92:150-5.
18. Altemir FH. The submental route for endotracheal intubation: A new technique. *J Maxillofac Surg* 1986;14:64-5.
 19. Meyer C, Valfrey J, Kjartansdorttir T, Wilk A, Barriere P. Indication for and technical refinements of submental intubation in oral and maxillofacial surgery. *J Cranio-Maxillofac Surg* 2003;31:383-8.
 20. Eipe N, Neuhoefer E, Rosee GL, Choudhrie R, Samman N, Kreusch T. Submental intubation for cancrum oris: A case report. *Pediatr Anesth* 2005;15:1009-12.
 21. Chandu A, Smith AC, Gebert R. Submental Intubation: An alternative to Short-Term Tracheostomy. *Anaesth Intensive Care* 2000;28:193-5.
 22. Arya VK, Kumar A, Makkar SS, Sharma RK. Retrograde submental intubation by pharyngeal loop technique in a patient with faciomaxillary trauma and restricted mouth opening. *Anesth Analg* 2005;100:534-7.
 23. Berkovitz Barry KB, editor. Triangles of neck. Neck. Chapter 31. In: Standring S, editor. *Gray's Anatomy. The Anatomical basis of Clinical Practice*. 39th ed. Edinburgh: Churchill Livingstone-Elsevier; 2005. p. 553.
 24. Berry MM, Standring S, Bannister LH, editors. Hypoglossal nerve, Figure no. 8.357. Nervous system (section 8). In: Banister LH, Mertin MM, editors. *Gray's Anatomy*. 38th ed. Edinburgh: Churchill Livingstone; 1995. p. 1257.
 25. Berry MM, Standring S, Bannister LH, editors. Lingual nerve. Nervous system (section 8). In: Banister LH, Mertin MM, editors. *Gray's Anatomy*. 38th ed. Edinburgh: Churchill Livingstone; 1995. p. 1239.
 26. Ramsay CA, Dhaliwal SK. Retrograde and submental intubation. *Atlas Oral Maxillary Surg Clin N Am* 2010; 18:61-8.
 27. Gadre KS, Waknis PP. Transmylohyoid/Submental intubation: Review, analysis, and refinements. *J Craniofac Surg* 2010; 21:516-9.
 28. Green JD, Moore UJ. A modification of sub-mental intubation. *Br J Anaesth* 1996;77:789-91.
 29. Scafati CT, Maio G, Alberti F, Scafati ST, Grimaldi PL. Submento-submandibular intubation: Is the subperiosteal passage essential? Experience in 107 consecutive cases. *Br J Oral Maxillofac Surg* 2006;44:12-4.
 30. MacInnis E, Baig M. A modified submental approach to oral endotracheal intubation. *Int J Oral Maxillofac Surg* 1999;28:269-72.
 31. Paetkau D, Strand M, Onc B. Submental orotracheal intubation for maxillofacial surgery. *Anaesthesiology* 2000;92:912-4.
 32. Mak PH, Ooi RG. Submental intubation in a patient with beta-thalassaemia major undergoing elective maxillary and mandibular osteotomies. *Br J Anaesth* 2002;88:288-91.
 33. Hanamoto H, Morimoto Y, Niwa H, Iida S, Aikawa T. A new modification for safer submental orotracheal intubation. *J Anesth* 2011;25:781-3.
 34. Drolet P, Girard M, Poirier J, Grenier Y. Facilitating submental endotracheal intubation with an endotracheal tube exchanger. *Anesth Analg* 2000;90:222.
 35. Nyarady Z, Sari F, Olasz L, Nyarady J. Submental endotracheal intubation in concurrent orthognathic surgery: A technical note. *J Cranio-Maxillofac Surg* 2006;34:362-5.
 36. Biswas BK, Joshi S, Bhattacharyya P, Gupta PK, Baniwal S. Percutaneous dilational tracheostomy kit: An aid to submental intubation. *Anesth Analg* 2006;103:1055.
 37. Amin M, Dill-Russell P, Mainsali M, Lee R, Sinton I. Facial fracture and submental tracheal intubation. *Anaesthesia* 2002;57:1195-212.
 38. Mahmood S, Lello GE. Oral endotracheal intubation: Median submental (retrogenial) approach. *J Oral Maxillofac Surg* 2002;60:473-4.
 39. Lima SM Jr, Asprino L, Moreira RW, de Moraes M. A retrospective analysis of submental intubation in maxillofacial trauma patients. *J Oral Maxillofac Surg* 2011;69:2001-5.
 40. Adeyemo WL, Ogunlewe MO, Desalu I, Akanmu ON, Ladeinde AL. Submental / Transmylohyoid intubation in maxillofacial surgery: Report of two cases. *Niger J Clin Pract* 2011;14:98-101.
 41. Altemir FH, Montero SH. The submental route revisited using the laryngeal mask airway: A technical note. *J Cranio-Maxillofac Surg* 2000;28:343-4.
 42. Hernández Altemir F, Hernández Montero S, Moros Peña M. Combitude SA through submental route. A technical innovation. *J Craniomaxillofac Surg* 2003;31:257-9.
 43. Malhotra N, Bhardwaj N, Chari P. Submental endotracheal intubation: A useful alternative to tracheostomy. *Indian J Anaesth* 2002; 46:400-2.
 44. Stranc MF, Skoracki R. A complicationsubmandibular intubation in a panfacial fracture patients. *J Cranio-Maxillofac Surg* 2001;29:174-6.
 45. Adelson RT. Submental intubation to facilitate the management of maxillofacial trauma. *Ear Nose Throat J* 2011;90:412-4.
 46. Gordon NC, Tolstunov L. Submental approach to oroendotracheal intubation in patients with midfacial fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;79:269-72.
 47. Labbe D, Kaluzinski E, Badie-Modiri B, Rakotonirina N, Berenger C. Intubation sous-mentale en traumatologie cranio-maxilo-facial Note technique. *Ann Chir Plast Esthet* 1998;43:248-51.
 48. Yoon KB, Choi BH, Chang HS, Lim HK. Management of detachment of pilot balloon during intraoral repositioning of the submental endotracheal tube. *Yonsei Med J* 2004;45:748-50.
 49. Manganello-Souza LC, Tenorio-Cabezas N, Piccinini Filho L. Submental method for orotracheal intubation in treating facial trauma. *Sao Paulo Med J* 1998;116:1829-32.
 50. Nwoku AL, Al-Balawi SA, Al-Zahrani SA. A modified method of submental oroendotracheal intubation. *Saudi Med J* 2002;23:73-6.
 51. Ball DR, Clark M, Jefferson P, Stewart T. Improved submental intubation. *Anaesthesia* 2003;58:189.
 52. Lim HK, Kim IK, Han JU, Kim TJ, Lee CS, Song JH, et al. Modified submental orotracheal intubation using the blue cap on the end of the thoracic catheter. *Yonsei Med J* 2003;44:919-22.
 53. Nyárady Z, Sári F, Olasz L, Nyárady J. Modified submental endotracheal intubation in concurrent orthognathic surgery. *Mund Kiefer Gesichtschir* 2004;8:387-9.
 54. Kim KF, Doriot R, Morse MA, Al-Attar A, Dufresne CR. Alternative to tracheostomy: submental intubation in craniomaxillofacial trauma. *J Craniofac Surg* 2005;16:498-500.
 55. Kim KJ, Lee JS, Kim HJ, Ha JY, Park H, Han DW. Submental intubation with reinforced tube for intubating laryngeal mask airway. *Yonsei Med J* 2005;46:571-4.
 56. Caubi AF, Vasconcelos BC, Vasconcellos RJ, de Moraes HH, Rocha NS. Submental intubation in oral maxillofacial surgery: Review of the literature and analysis of 13 cases. *Med Oral Patol Oral Cir Bucal* 2008;13:E197-200.
 57. Schütz P, Hamed HH. Submental intubation versus tracheostomy in maxillofacial trauma patients. *J Oral Maxillofac Surg* 2008; 66:1404-9.
 58. Chandu A, Witherow H, Stewart A. Submental intubation in orthognathic surgery: Initial experience. *Br J Oral Maxillofacial Surg* 2008;46:561-3.
 59. Babu I, Sagtani A, Jain N, Bawa SN. Submental tracheal intubation in a case of panfacial trauma. *Kathmandu Univ Med J (KUMJ)* 2008;6:102-4.
 60. Sharma RK, Tuli P, Cyriac C, Parashar A, Makkar S. Submental tracheal intubation in oromaxillofacial surgery. *Indian J Plast Surg* 2008;41:15-9.
 61. Elizár'eva NL, Rovina AK, Levin OB, Kolosov AN. [Submental

- tracheal intubation is an alternative to tracheostomy in oral surgery]. *Anesteziol Reanimatol* 2008;3:22-5.
62. Langford R. Complication of submental intubation. *Anaesth Intensive Care* 2009;37:325-6.
 63. Uma G, Viswanathan PN, Nagaraja PS. Submandibular approach for tracheal intubation-A Case Report *Indian J Anaesth* 2009; 53:84-7.
 64. Garg M, Rastogi B, Jain M, Chauhan H, Bansal V. Submental intubation in panfacial injuries: our experience. *Dent Traumatol* 2010;26:90-3.
 65. Navaneetham A, Thangaswamy VS, Rao N. *J Maxillofac Oral Surg* 2010;9:64-7.
 66. Agrawal M, Kang LS. Midline submental orotracheal intubation in maxillofacial injuries: A substitute to tracheostomy where postoperative mechanical ventilation is not required. *J Anaesthesiol Clin Pharmacol* 2010;26:498-502.
 67. Shetty PM, Yadav SK, Upadya M. Submental intubation in patients with panfacial fractures: A prospective study. *Indian J Anaesth* 2011;55:299-304.

How to cite this article: Das S, Das TP, Ghosh PS. Submental intubation: A journey over the last 25 years. *J Anaesthesiol Clin Pharmacol* 2012;28:291-303.
Source of Support: Nil, **Conflict of Interest:** None declared.

Author Help: Online submission of the manuscripts

Articles can be submitted online from <http://www.journalonweb.com>. For online submission, the articles should be prepared in two files (first page file and article file). Images should be submitted separately.

1) **First Page File:**

Prepare the title page, covering letter, acknowledgement etc. using a word processor program. All information related to your identity should be included here. Use text/rtf/doc/pdf files. Do not zip the files.

2) **Article File:**

The main text of the article, beginning with the Abstract to References (including tables) should be in this file. Do not include any information (such as acknowledgement, your names in page headers etc.) in this file. Use text/rtf/doc/pdf files. Do not zip the files. Limit the file size to 1024 kb. Do not incorporate images in the file. If file size is large, graphs can be submitted separately as images, without their being incorporated in the article file. This will reduce the size of the file.

3) **Images:**

Submit good quality color images. Each image should be less than **4096 kb (4 MB)** in size. The size of the image can be reduced by decreasing the actual height and width of the images (keep up to about 6 inches and up to about 1800 x 1200 pixels). JPEG is the most suitable file format. The image quality should be good enough to judge the scientific value of the image. For the purpose of printing, always retain a good quality, high resolution image. This high resolution image should be sent to the editorial office at the time of sending a revised article.

4) **Legends:**

Legends for the figures/images should be included at the end of the article file.