Advances in videoassisted anterior surgical approach to the craniovertebral junction

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With 3 Figures

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Abstract

At the present time, an update to the classical microsurgical transoral decompression is supported by the most recent literature dealing with the introduction of the endoscopy in spine surgery. In this paper, we present all the reported experience on the surgical approaches to anterior craniovertebral junction (CVJ) compressive pathology managed by endoscopy. Surgical strategies dealing with decompressive procedures by using an open access, microsurgical technique, neuronavigation and endoscopy are summarized.

Endoscopy represents a useful complement to the standard microsurgical approach to the anterior CVJ. Endoscopy can be used via transnasal, transoral and transcervical routes; it facilitates visualisation and better decompression without the need for soft palate splitting, hard palate resection, or extended maxillotomy. Although neuronavigation enhances orientation within the surgical field, intraoperative fluoroscopy helps to recognize residual compression.

Under normal anatomical conditions, there appear to be no surgical limitations for the endoscopically assisted transoral approach compared with the pure endonasal and transcervical endoscopic approaches.

The endoscope has a clear role as "support" to the standard transoral microsurgical approach since 30° angulated endoscopy increases the surgical area exposed over the posterior pharyngeal wall and the extent of the clivus.

Keywords: Craniovertebral junction; trans-oral approach; transnasal approach; transcervical approach; endoscopy.

Introduction

The transoral approach to the posterior pharyngeal wall has been used for years to drain retropharyngeal abscesses, but it was not until the 1940s that it was first used in the treatment of spinal abnormalities [18]. In 1962, Fang and Ong [5] published the first series of patients to undergo transoral decompression for irreducible atlantoaxial abnormalities. The high rate of morbidity and mortality caused poor acceptance of the transoral approach as a means for decompression of cervicomedullary junction abnormality.

Popularized by Crockard, the *microsurgical* ventral approach to the CVJ has been widely described for decompression of irreducible extradural pathology [3]. The shortest and most physiological route to the ventral aspect of the CVJ is represented by an anterior approach through the pharynx. The use of the operating microscopes, high-speed drills, self-retaining mouth retractors, flexible oral endotracheal tubes, intraoperative fluoroscopy, and electrophysiological monitoring has made this procedure much more safer [17]. A number of anterior approaches have been described to allow exposure to the midline and lateral aspects of both the cranial base and upper cervical spine [16].

The transoral-transpharyngeal approach, a technique that is well known to many spine surgeons, provides surgical access to the anterior clivus, C1, and C2. Transoral approaches provide the fundamental anatomy and technique upon which the more complex jaw-splitting approaches are based (i.e. "transoral extended approaches" with transmaxillary and transmandibular extentions). The transoral-transpharyngeal approach historically remains the "gold standard" for anterior approaches to the cervical spine.

However, there are still technical difficulties with the operating microscope, such as the need to see and work through a narrow opening in a deep cavity; to improve visualization, soft-palate splitting and even hard-palate resection along with extended maxillotomy are occasionally required.

To overcome such complications, endoscopic assisted procedures for CVJ decompression have been developed starting from the experience with the use of the endoscope for transsphenoidal pituitary surgery and cervical spine. An update to the concept of classical transoral microsurgical decompression is now strongly provided by the most recent literature dealing with the introduction of the endoscopy in spine surgery.

Classic transoral microsurgical approach

Historically Menezes outlined several factors influencing the specific treatment of anterior CVJ compressive abnormalities. These included: (1) the reducibility of the lesion, i.e., whether anatomic alignment be restored thus alleviating the compression, (2) the direction and the mechanics of the compression, (3) the etiology of the compression, and (4) the presence of ossification centers. The approach to the lesion is dictated by the location and nature of the compression [12]. When preoperative dynamic neuroradiological examinations demonstrate that the CVJ compression is reducible, neural decompression may be obtained by simply reducing the dislocation as well as by stabilizing the CVJ with a posterior instrumentation, either with wires, claws or screws ("functional decompression"); otherwise anterior decompression is required [12, 19–22].

The huge Menezes' experience on transoral approach was started in 1977 and up to the 2008 the number of the microsurgical procedures has been calculated to be 732 (280 children) [13]. This author in his paper concluded that the ventral transoral-transpalatopharyngeal approach has evolved into a safe, rapid, effective and direct approach to the ventral irreducible pathology of CVJ with minimal morbidity and mortality. Although there have been recent attempts at obtaining better visualization and reducing the surgical morbidity with endoscopically assisted procedures, Menezes has not felt the need for any of those. In his opinion, in addition, intra-operative fluoroscopy or the use of "Stealth technology" has been of little value because, of the marked improvement in the three-dimensional imaging.

Menezes concludes that the advantages of the transoral-transpalatine approach to the craniocervical region compared with other operative approaches in irreducible pathology are that: (1) the impinging bony pathology and granulation tissue that accompanies chronic instability is easily accessible, (2) the patient is placed in the extended position as opposed to the flexed position, thus, decreasing the angulation on the brain stem during surgery, and (3) surgery is performed through the avascular median raphe and through the clivus [12, 13, 23].

Endoscopy (dealing with "minimally invasive surgery") means *looking inside* and typically refers to looking inside the body for medical reasons using an endoscope, an instrument used to examine the interior of a hollow organ or cavity of the body. It was used as early as the ancient Greek and Roman periods. An instrument considered a prototype of endoscopes was evidenced and discovered in the ruins of Pompei. It was Philip Bozzini who in 1805 made the first attempt to observe the living human body directly through a tube he created known as a Lichtleiter (light guiding instrument) to examine the urinary tract, rectum and pharynx. Unlike most other medical imaging devices, endoscopes are inserted directly into the organ and it In the early 1950s it was first designed a "fibroscope" (a coherent bundle of flexible glass fibres able to transmit an image), which led to further improvements in image quality. Further innovations included using additional fibres to chanel light to the objective end from a powerful external source along with and 0°–30°–45° lens – thereby achieving the high level of full spectrum illumination and oriented vision that was needed for detailed viewing and colour photography. It was the beginning of key-hole surgery as we know it today [1, 6–8, 10, 11, 14].

Rationale

Contrary to Menezes' experience, some papers claim *significant* oropharyngeal morbidity from splitting the soft palate associated with the transoral approach. Jones reported a striking difference in oropharyngeal complications when analyzed with regard to splitting of the soft palate (no splitting vs. splitting complication rate: 1/5); oropharyngeal complications dropped to a 15.4% in those patients who did not undergo splitting of the soft palate, as compared with 75% in the split soft palate group. The Author concludes that this procedure should be discontinued where it is not absolutely necessary [9].

The surgical risks dealing with the *lateral exposure* (toughly 15 to 20 mm bilaterally off the midline from the inferior clivus to the C3 body) consists of trauma to (1) the Eustachian tube orifice, (2) hypoglossal nerve, (3) vidian nerve, (4) vertebral artery at the C1–C2 interface; those dealing with the *longitudinal exposure* (due to soft palatal splitting with velopalatine incompetence) consist of (1) nasal speech (2) dysphagia, (3) regurgitation of liquids [15].

Endoscopic assisted procedures

Endoscopic endonasal, transoral and transcervical approaches developed recently as promising alternatives to the classic microsurgical transoral approach to the CVJ that may become more mainstream as experience with these approaches increases (cons: learning curve, loss of 3-dimensional visualization).

Endonasal

The increased diffusion in the use of the endoscope for transsphenoidal pituitary surgery led some studies to explore the possibility of applying the endoscopic endonasal approach in the surgical treatment of skull base lesions other than pituitary tumors. In recent years some papers have reported anatomical studies and surgical experience in the endoscopic endonasal approach to different areas of the midline skull base, from the olfactory groove to the CVJ [14]. In 2002, Alfieri was the first to perform a cadaveric study on totally transnasal endocopic odontoidectomy through one or two nostril routes, by following the Jho's endonasal paraseptal technique [8]. Rodlens endoscopes, which were 2.7 or 4 mm in diameter, 18 cm in length with 0-, 30-, and 70-degree lenses, were used. The surgical landmarks leading to the craniocervical junction were the inferior margin of the middle turbinate, nasopharynx and the Eustachian tubes. The nasopharynx was readily identified following the inferior margin of the middle turbinate. The line drawn between the Eustachian tubes indicated the juncture between the clivus and atlas. The Author concluded that

> *"... contrary to a conventional transoral approach, this endoscopic endonasal approach provides unlimited access to the midline clivus and a potential of carrying out surgical decompression at the ventral craniocervical junction without adding C1-2 instability"* [23].

Three years later Cavallo confirmed such an observation on cadaveric study [2].

After the intuition of Alfieri, in 2005 Kassam operated the first case through a fully transnasal endoscopic resection of the odontoid in a 73-year old woman affected by rheumatoid arthritis [1, 10]. In his historical report, Kassam's recommended equipment consisted of (1) navigation system; (2) a zero degree endoscope; (3) long angled endonasal drill, (4) ultrasonic aspirator; (5) bayoneted handheld microinstrumentation and concluded: "The transoral approach remains the "gold standard" but in contrast with this "... *the defect created by transnasal approach is above the level of soft palate and should not be exposed to the same degree of bacterial contamination*".

Further anatomic studies performed by Messina one year later concluded that similar to the transoral approach, the endoscopic endonasal provides a

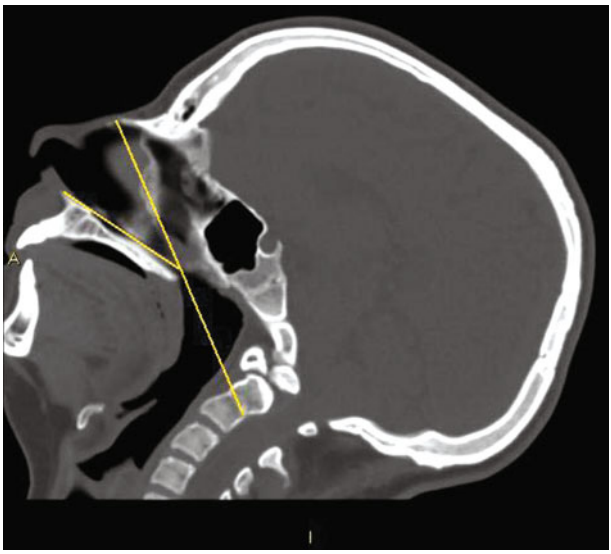

Fig. 1. The nasopalatine line is measured by connecting the most inferior point on the nasal bone to the most posterior point on the hard palate in the midsagittal plane (see text)

direct route to the surgical target, but it seems related to less morbidity. Nevertheless, as matter of fact thinks are less simple. The group of Kassam pulished in 2009 the concept of the "Nasopalatine line" (NPL) which is the line created by connecting the most inferior point on the nasal bone to the most posterior point on the hard palate in the midsagittal plane. Intersection of this line with the vertebral column is measured relative to the inferior aspect of the body of C2 along its posterior surface (Fig. 1) [4]. The NPL is a reliable predictor of the maximal extent of inferior dissection, and odontoid surgery can reliably be performed according to the preoperative radiological study of the possible anatomical limitations of the endonasal approach. This approach is recommended by the Authors *in selected* cases as valid alternative to the transoral microscopic approach for the resection of the odontoid process of C2 and should be performed only by *surgeons very skilled in endoscopic endonasal surgery and in endoscopic cadaver-dissections* [17, 20] (Fig. 2A).

Indications, advantages/disadvantages side-effects, putative complications

According to Kassam, the approach originally described, was applicable to the selected group of rheumatoid patients presenting with brainstem compression who had clinical progression of disease despite posterior spinal fixation, significant bony compression from pannus formation, or a significant anterior vector

of pannus. Furthermore in the author's indications the associated pathologies for endoscopic transnasal resection of the odontoid included also tumors in the region of the foramen magnum, vertebrobasilar aneurysms that not ablated by endovascular treatment, dens displacement secondary to C1/C2 traumatic fracture and other occipitocervical anomalies associated with anterior cervicomedullary compression, such as os odontoideum, atlantal assimilation, and basilar invagination. To be highlighted that the endonasal approach to the odontoid can even be performed in the presence of the retro pharyngeal location of internal carotid arteries. Relative contraindications to a transnasal endoscopic odontoid resection include tumors lateral to, or encasing, the extracranial vertebral arteries, or pathology existing inferior to C2. In general, the expanded endonasal approach offers a number of advantages to the traditional open, transoral approach, including improved visualization, decreased airway and swallowing morbidity, preservation of palatal function, decreased postoperative pain, and reduced duration of hospitalization. With the incision performed above the soft palate, should limit postoperative swallowing dysfunction and minimize exposure to oral bacterial flora; moreover it is possible to remove the odontoid process without disturbing the C1 ring due to the more caudal surgical route. Of course, there are putative risks with this surgery, which include possible cerebrospinal fluid leak from aggressive pannus resection or dural tear, cervical instability, and vascular injury. These risks are shared by other approaches and can be effectively managed with the endonasal.

Summary

Pros: partial isolation of the oral cavity, no needs of tracheostomy and reduced need of feeding tube. Cons: oblique approach, only piecemeal removal of CVJ pathology is allowed, not recommended for large tumors and low sited CVJ pathologies.

Transoral

The 30-degree endoscope has been proposed for transoral approach to avoid full soft-palate splitting, hard-palate splitting, or extended maxillo/mandibulotoy [7]. Using the endoscope, the operator is able to look in all directions by rotating the instrument. Because the light source is at the level of the abnormality, superior illumination can be obtained. With the aid of an endoscope, abnormalities as high as the midclivus can be visualized without extensive soft- or hard-palate manipulation.

The last high profile cadaveric study recently available in the Literature is the one of the Ammirati Group which quantifies the surgical volume gained by this approach: the surgical area exposed over the posterior pharyngeal wall is significantly improved using the endoscope (606.5–127.4 mm^3) compared

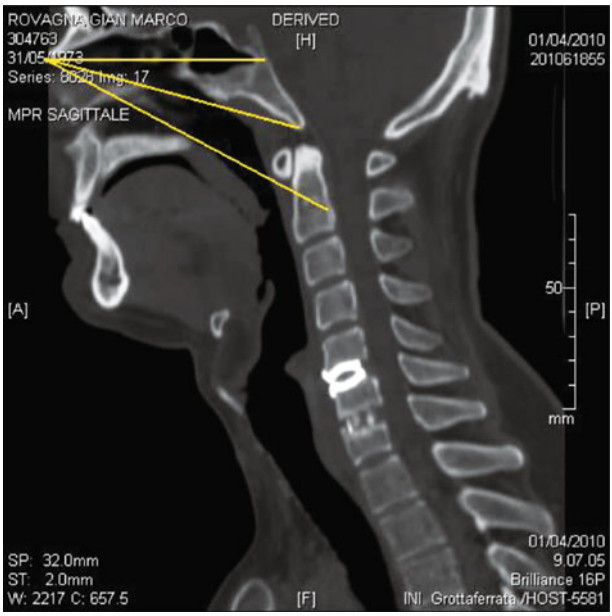

Fig. 2A. Computed tomographic scans demonstrating the surgical trajectory and angles for the endonasal approach (personal observation)

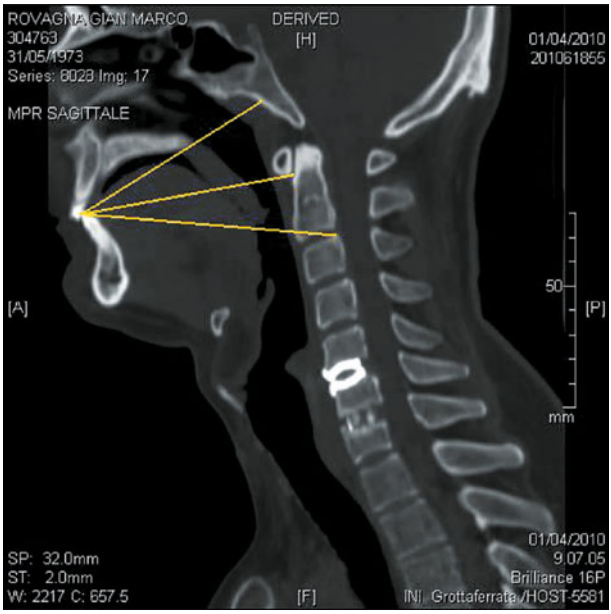

Fig. 2B. Computed tomographic scans demonstrating the surgical trajectory and angles for the the transoral approach (personal observation)

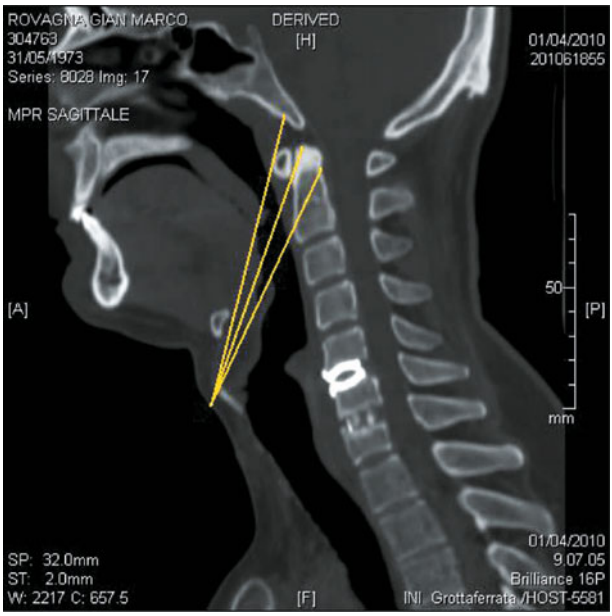

Fig. 2C. Computed tomographic scans demonstrating the surgical trajectory and angles for the transcervical approach (personal observation)

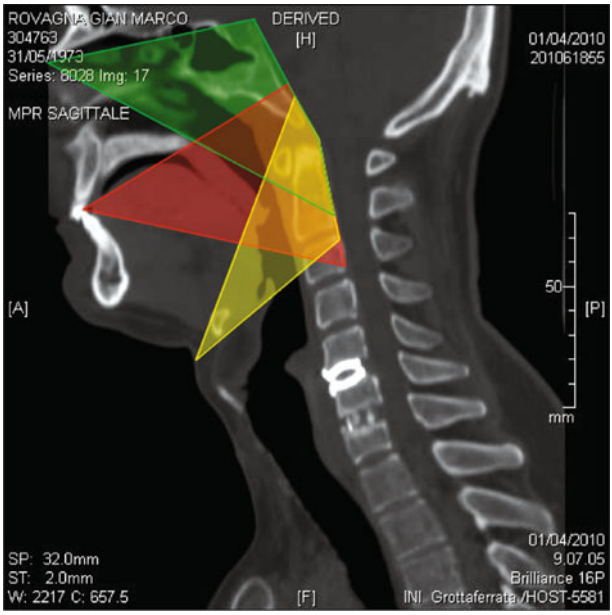

Fig. 2D. Common surgical area of the 3 approaches is represented by the overlapping illumination

with the operating microscope (425.7 100.8 mm^3), without any compromise of surgical freedom (*P* 0.05). The extent of the clivus exposed with the endoscope (9.5 0.7 mm) without splitting the soft palate is significantly improved compared with that associated with microscopic approach (2.0 0.4 mm) (*P* 0.05) [17]. With this paper it is well demonstrated that with the aid of the endoscope and image guidance, is it possible to approach the ventral CVJ transorally with minimal tissue dissection, no palatal splitting, and no compromise of surgical freedom. In addition, the use of an angled-lens endoscope can significantly improve the exposure of the clivus without splitting the soft palate (Figs. 2B, 3).

Indications, advantages/disadvantages side-effects, putative complications

Virtually no surgical limitations do exist for endoscopically assisted transoral approach, compared with the pure endonasal and transcervical approaches.

Of course, there are putative risks with this surgery, which include possible cerebrospinal fluid leak from aggressive pannus resection or dural tear, cervical instability, and vascular injury. These risks are shared by other approaches and can be effectively managed with the endonasal. To be highlighted that alternative procedures must be required (i.e., endonasal or transcervical endoscopic approach) in the presence of the retro pharyngeal location of internal carotid arteries.

Summary

Pros: direct approach, radical removal of huge tumors, good visualization and comfortable mobilization of surgical tools. Cons: possible need of tracheostomy, need of feeding tube, difficult management of very high invagination conditions with platibasia.

Transcervical

Wolinsky first described in 2007 an alternative endoscopic route to the anterior CVJ with the endoscopic transcervical approach [24]. The need of this option deals with the limitation of transpharyngeal approaches above mentioned. When the pharynx is traversed, the operative field is virtually contaminated with oral flora. Risk for infection, poor pharyngeal healing, and meningitis (if the dura is transgressed) can all be increased. Moreover the transcervical exposure is familiar to neurosurgeons, and the trajectory proposed by the Author allows deep-seated basilar invaginations to be decompressed [11]. The endoscopic odontoidectomy via a standard anterior cervical approach has been described as the evolution of the procedure used for a transodontoid screw (Fig. 2C).

Indications, advantages/disadvantages side-effects, putative complications

According to Wolinski the endoscopic transcervical odontoidectomy has many advantages over the conventional approaches to odontoid resection: the exposure is familiar to neurosurgeons. It does not require traversing the oral mucosa and therefore theoretically decreases the chance of postoperative meningitis in the setting of an inadvertent or intentional breach of the dura mater. In addition, the trajectory of the approach should allow even the deepest of basilar invaginations to be decompressed. The postoperative recovery time is shorter compared to other techniques. Patients are able to ingest food orally shortly after removal of the endotracheal tube. In patients without preoperative dysphagia, there is no need for a tracheostomy or gastric or duodenal feeding tube as a result of the procedure. The risk of postoperative phonation difficulty that is present in a transoral approach is avoided with a transodontoid approach. The risk of injury to the recurrent laryngeal nerve is present but is the same as in an anterior cervical approach. Using a transodontoid approach, more caudal vertebral body resection (below the odontoid) is possible through the same incision because the technique exposes C1 through C4 ventrally, and the exposure can be easily extended to provide access caudal to C4. Not all patients are candidates for this approach. As in the case of transodontoid screw placement, the trajectory may not be achieved in patients who are obese, barrel-chested, or severely kyphotic. Nevertheless the odontoid decompression is too oblique and

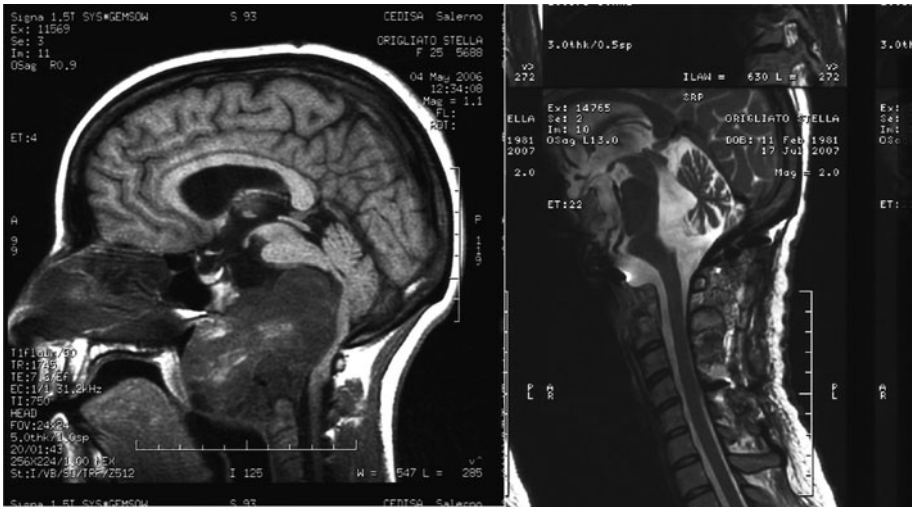

Fig. 3. Huge chordoma in 26 yrs lady before (*left*) and after (*right*) endoscopic assisted transoral microsurgical approach, not suitable for endoscopic endonasal and transcervical approach (personal observation)

partial although without disturbing the C1 ring. To gain access to the lower clivus C1 ring has to be removed but the angle of attack makes this portion of dissection most difficult or impossible. Finally, in our opinion, in cases of impression basilaris or other high pathologies such an approach could be uncomfortable and challenging. Of course, possible cerebrospinal fluid leak from aggressive pannus resection or dural tear, cervical instability, and vascular injury must be put into consideration (Fig. 2D).

Conclusion

Pros: complete isolation of the oral cavity, no needs of tracheostomy and feeding tube. Cons: oblique approach, only piecemeal removal of CVJ pathology is allowed, not recommended for large tumors, obese, barrel chested and severely kyphotic patients (Fig. 3).

Considerations

The progressive worldwide blooming of transoral procedures, thanks to the intensive care and the intraoperative neurophysiological monitoring techniques improvements (once considered pioneering and very selective), are spreading the expertise in this surgery to a new population of surgeons. New trends in technology drive from the "old fashioned referenced" micro surgeons to the young spine surgeons, more committed in video-assisted and minimally invasive procedures.

As far as possible to summarize from the literature and conclude according to personal experience, although blooming in the worldwide literature, pure endonasal and cervical endoscopic approach deserve consideration but still has some disadvantages: (1) the learning curve and (2) the lack of 3-dimensional perception of the surgical field which could be an operationally limiting factor. Image clarity will be diminished when endoscopes smaller than 2.7 mm are used. Standard 4-mm endoscopes give a good image quality, but 2.7-mm scopes provide better maneuverability; (3) a limited working channel, according to the variability of the nasopalatine line, which can make difficult to remove huge tumors like the one shown in Fig. 3.

In our opinion endoscopically assisted transoral surgery with 30° endoscopes represents an emerging alternative to standard microsurgical techniques for transoral approaches to the anterior CVJ. Used in conjunction with traditional microsurgery and intraoperative fluoroscopy, it provides a safe and improved method for anterior decompression *without or with a reduced* need for extensive soft palate splitting, hard palate resection, or extended maxillotomy. Virtually no surgical limitations do exist for endoscopically assisted transoral approach, compared with the pure endonasal and transcervical approaches.

So far, the endoscope deserves an interesting role as "support" to the standard transoral microsurgical approach since 30° angulated endoscopy strongly improve the *visual but not the working channel and volume.*

Consequently, although we take advantage by endoscopy, we continue to perform the soft palate splitting, since at the maximum follow up, no one patient complained nasal speech, dysphagia or regurgitation of liquids.

Transoral (videoassisted) approach still remain the gold standard compared to the "pure" transnasal and transcervical approaches due to the wider working channel provided by the former technique. Experience is required with greater numbers of patients and long-term follow-up to further validate this promising technique.

Furthermore, the use of image guidance systems before surgery allows a correct planning and during endoscopic procedures gives the surgeon a constant orientation in the surgical field, thus increasing the accuracy and the safety of the approach, although the use of contrast medium fluoroscopy "per se" represents an "ever green" old fashion image guidance system still effective.

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