Transoral Versus Transnasal Approach for Craniovertebral Junction Pathologies: Never Say Never

Massimiliano Visocchi[1], Francesco Signorelli[1], Chenlong Liao[2], Mario Rigante[3], Gaetano Paludetti[3], Giuseppe Barbagallo[4], Alessandro Olivi[1]

■ OBJECTIVE: **For many years, the microsurgical transoral approach (TOA) has been accepted as the "gold standard" for the surgical treatment of a variety of congenital, developmental, and acquired pathologies affecting the craniovertebral junction. In the present study, we try to investigate both experimental and clinical fronts of such a challenging surgery, starting from the updated literature experience. TOA is actually presented as an "old-fashioned" surgical technique dealing with possible bacterial contamination, the need of postoperative nose gastric tube feeding for a week, the possible nasopharyngeal incompetence, and the postoperative tongue swelling. Otherwise, the endoscopic endonasal approach (EEA) appears strongly supported by the modern literature as the true "minimally invasive" procedure.**

■ METHODS: **Our clinical experience deals with 23 anterior procedures in paediatric and adult patients (17 TOA and 6 EEA). We further report on our experimental cadaver laboratory study of 12 subjects.**

■ RESULTS: **All the patients of TOA group but one were discharged after posterior procedures within two weeks and improved or remained unchanged after surgery and during the follow-up. No mayor complications occurred in TOA group. In EEA group two patients died for cerebrospinal fluid infection, for disease progression and for heart attack.**

■ CONCLUSION: **Our and other available data suggest that no clear superiority of EEA over endoscopic TOA can be assessed so far; on the other hand, EEA can produce complications similar to TOA in craniovertebral junction surgery.**

INTRODUCTION

For many years, the microsurgical transoral approach (TOA) has been accepted as the "gold standard" for the surgical treatment of a variety of congenital, developmental, and acquired pathologies affecting the craniovertebral junction (CVJ). This surgery, although burdened by possible bacterial contamination, the need of postoperative nose gastric tube feeding for a week, the possible nasopharyngeal incompetence, and the postoperative tongue swelling, was strongly supported by the clinical introduction by Kassam et al.[1] regarding the endoscopic endonasal approach (EEA).[1] The EEA appeared potentially promising in overcoming previous technical challenges and surgical complications, progressively gaining favor over TOA; however, the exact role of this approach in the treatment of CVJ pathology is yet to be defined. In 2009, the de Almeida et al.[2] introduced the nasopalatine line (NPL), connecting the most inferior point on the nasal bone and the most posterior point on the hard palate toward the inferior aspect of the body of C2, as a reliable predictor of the maximal extent of inferior dissection. Odontoid surgery can be performed reliably according to the preoperative radiologic study of the possible anatomic limitations of the endonasal approach. Moreover, a novel "surgical" nasoaxial Line (NAxL) was conceived to be obtained preoperatively and radiologically to overcome the

Key words
- CVJ pathologies
- Endoscopy
- Transoral approach

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
CVJ: Craniovertebral junction
EEA: Endoscopic endonasal approach
AxL: Nasoaxial line
NPL: Nasopalatine line
PIA: Palatine inferior dental arch line
TOA: Transoral approach

From the [1]Institute of Neurosurgery Catholic University of Rome, Rome, Italy; [2]Department of Neurosurgery, Xinhua Hospital, Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China; [3]Institute of Otolaryngology, Catholic University of Rome, Rome, Italy; [4]Division of Neurosurgery, Department of Neurosciences, Policlinico "G.Rodolico" University Hospital, Catania, Italy

To whom correspondence should be addressed: Francesco Signorelli, M.D. [E-mail: francesco.signorelli1984@gmail.com]

Citation: World Neurosurg. (2018) 110:592-603.
http://dx.doi.org/10.1016/j.wneu.2017.05.125

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

imprecision of the NPL.[3,4] Otherwise, no conceptually analogue radiologic line has been introduced as a reliable predictor of the maximal superior extension of the transoral approach.

We report on our experimental and surgical experience with TOA and EEA for different CVJ pathologies, and we discuss the pertinent literature critically assessing the feasibility, advantages, and limitations of this approach. Although the available reports are limited, most of which are single cases or case series including relatively small number of patients, we try to demonstrate that TOA still deserves a high consideration and that, in some cases, it can be considered superior to EEA.

RATIONALE AND METHODS

Experimental Study

The aim of our experimental study, for which preliminary data were published in 2015,[5] was 1) to verify the introduction of the palatine inferior dental arch line (PIA), the conceptual analogue of NPL, as a reliable predictor of the maximal superior extension of the transoral approach; 2) to compare the radiologic with surgical NPL (SNPL) and PIA; 3) to compare our surgical NPL to the NAxL; 4) to find possible radiologic reference points to predict preoperatively the maximal extent of superior dissection for the transoral approach (surgical PIA); and 5) to compare radiologically the surgical exposition angle and the working channel volume of both transnasal and transoral approaches. After obtaining the ethical committee approval of the experimental protocol by the Catholic University of Rome, Italy (protocol number P663/CE/2010 approved on July 28, 2010; subsequent amendment number P437/CE 2012 approved on May 2, 2012), 12 fresh nonperfused cadavers (5 female and 7 male, median age of 75 years; interquartile range 35; minimum 42, maximum 98), were studied in the sectorial room of the Institute of Anatomy and Pathology at our university. In supine position with the head slightly extended (approximately 25 degrees), the Crockard transoral distractor (Crockard Transoral Instrument Set; Codman and Shurtleff, Raynham, Massachusetts, USA) was inserted in the oral cavity to expose the CVJ. The tubercle of C1 was identified with the finger in all the cadavers, and the position of the distractor was chosen according to the fluoroscopic assessment (MPX+ portable X-ray unit; Philips Healthcare, Best, The Netherlands).

In order to find a reference line for transolar analogous to NPL for transversal, we conceived a new PIA from the inferior dental arch up to the hard palate for preoperative transoral approach planning.[2,6] The radiologic NPL and PIA lines were evaluated using radiography and computed tomography (GE LightSpeed VCT 64 Slice, 1.25 mm thin; General Electric, Milwaukee, Wisconsin, USA). Subsequently 2 thin stainless probes mimicking the endoscopic tools (30 cm long) were inserted through the nostrils (choanae) and the oral cavity, as exposed by the Crockard distractor. The surgical NPL and PIA were then evaluated and compared radiologically[6] (**Figure 1**). The values (in degrees) of the angular exposure of the transoral and the transnasal approaches were evaluated for each subject by the lateral reconstructions. Percentage differences between the radiologic and surgical NPLs were evaluated along with the radiologic and surgical NPL ratio. The same was done for radiologic and surgical PIA (**Table 1**).

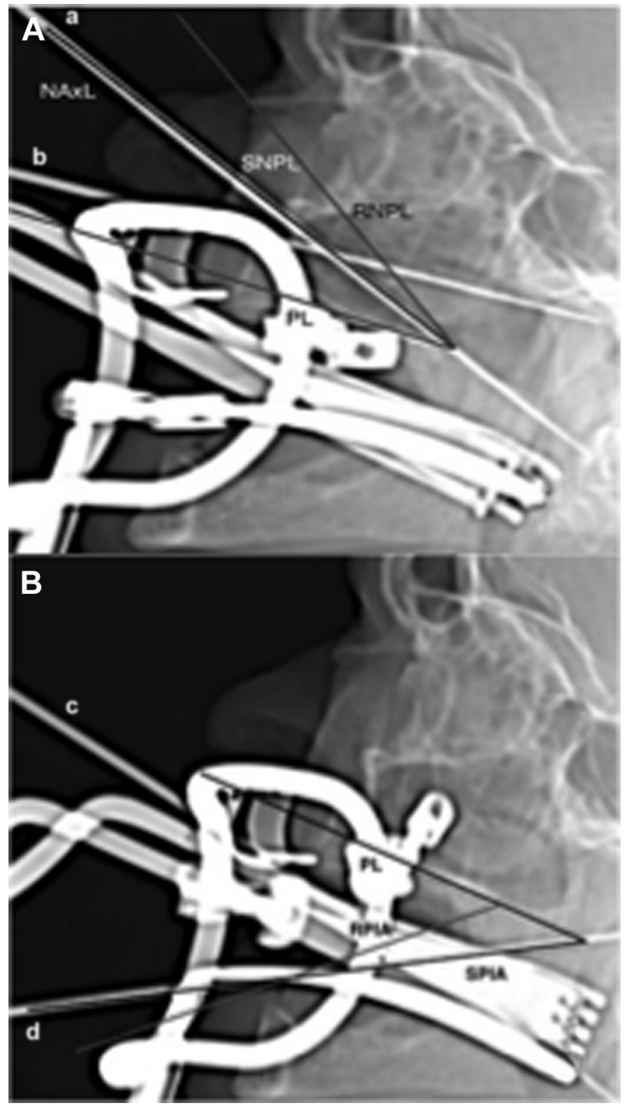

Figure 1. (**A**) Transnasal approach demonstrating (a) a surgical probe forced caudally and (b) a surgical probe forced cranially. Comparison between radiologic NPL (*continuous line*; angle, 38.7668 degrees) and surgical NPL (*continuous line*; angle, 22.5698 degrees). There is a difference of 16.197 degrees between the theoretical and real angular surgical domains. The NAxL (*dotted line*) coincide with the surgical NPL. The Crockard transoral distractor is visible. (**B**) Transoral approach demonstrating (c) a surgical probe forced caudally and (d) a surgical probe forced cranially. Comparison between radiologic PIA (angle, 36.2338 degrees) and surgical PIA (angle, 29.1588 degrees). There is an insignificant difference of 7.0758 between theoretical and real angular surgical domain. The Crockard transoral distractor is visible. Line c correspond to Atlas Superior dental Arch. NPL, nasopalatine line; NAxl, nasoaxial line; PIA, palatine inferior dental arch line.

Furthermore, we also evaluated the NAxL, defined as the line in the midsagittal plane that starts from the midpoint of the distance from the rhinion to the anterior nasal spine of maxillary bone and ends on C2 vertebra, tangential to the posterior nasal spine of palatine bone, and compared it with the surgical NPL.[4] Collected

Table 1. Cadaveric Study

Age (years)	Sex	RNPL (degrees)	SNPL (degrees)	SNPL/RPNL	NAxL/SNPL	RPIA (degrees)	SPIA (degrees)	SPIA/RPIA
75	Male	39	23	0.59	1	59	49	0.83
42	Male	34	23	0.68	1	36	29	0.81
51	Male	36	24	0.67	1	45	39	0.86
69	Female	41	27	0.66	1	54	44	0.81
55	Male	38	24	0.63	1	49	39	0.79
98	Female	36	27	0.75	1	46	39	0.84
79	Female	33	22	0.67	1	41	36	0.87
80	Male	34	25	0.74	1	46	41	0.89
56	Female	37	23	0.62	1	48	36	0.75
90	Female	36	22	0.61	1	48	37	0.77
69	Male	34	23	0.66	1	44	39	0.89
81	Male	39	24	0.61	1	51	40	0.78
Mean		36.4	23.9	0.66	1	47.2	39	0.83

RNPL, radiologic nasopalatal line; SNPL, surgical nasopalatal line; NAxL, nasoaxial line; RPIA, radiologic palatine inferior dental arch; SPIA, surgical palatine inferior dental arch line.

data were statistically analyzed. A descriptive analysis of the sample was completed using median, interquartile range, and range for continuous variables, and absolute and relative frequencies for qualitative ones (Table 2). To find statistically significant differences between the 2 surgical approaches, we performed a Wilcoxon signed-rank test. We decided to use a nonparametric test because data were not normally distributed, as demonstrated with a Shapiro—Wilk test.[7] The analysis was performed using SPSS software version 12.0 for Windows, and statistical significance level was set at $P = 0.05$.

Moreover, using thin stainless probes (30 cm long) inserted through the nostrils and the oral cavity, the transnasal and the transoral maximum linear and angled exposure of CVJ were evaluated for each subject by the lateral and the anterior X-rays (Figures 2 and 3; Tables 3 and 4).

Clinical Study

Among 23 anterior procedures (22 patients) performed from 2011 to 2017, a consecutive series of 6 patients with varied CVJ pathologies have been treated with an EEA approach and 17 patients with TOA treated by a mixed team of neurosurgeons and rhinolaryngologists with expertise in microneurosurgery and endoscopic video-assisted microsurgery (Tables 5 and 6).

Table 2. Statistical Analysis

	RNPL	SNPL	RPIA	SPIA
Median (IQR)	37.45 (3—57)	24.75 (3—07)	47.60 (4—83)	38.25 (3—38)
Wilcoxon signed-rank test (*P* value)	0.05	—	0.05	—

RNPL, radiologic nasopalatal line; SNPL, surgical nasopalatal line; RPIA, radiologic palatine inferior dental arch; SPIA, surgical palatine inferior dental arch line; IQR, interquartile range.

After transoral endotracheal intubation, the patients were placed in supine position, the head was pinned in the Mayfield head holder in neutral position. Next, the midface, forehead, and nose were shaved with antiseptic solution.

Intraoperative neuronavigation (Medtronic StealthStation, Louisville, Colorado, USA) and 0° and 30° rod lens endoscope (Karl Störz, Tuttlingen, Germany) were used. A surgical microscope (Zeiss Pentero, Oberkochen, Germany) was also used only in TOA surgery.

Endoscopic Endonasal Approach. In all cases, the 4-hands technique through two nostrils was used to resect the CVJ disease. After a midline incision of the mucosa, the anterior arch of C1 and the odontoid process were removed. Closure was achieved by approximating the mucosal layers with fibrin glue.

Transoral Approach. The tubercle of C1 was identified in all but 1 patient (who had a huge infiltrating tumor) with the aid of the neuronavigation system. Using microscopy, a midline longitudinal incision on the posterior pharyngeal wall was performed, and the longus colli and longus capitis muscles were mobilized laterally and held in place with tooth-bladed lateral pharyngeal retractors (Crockard TM Transoral Instrument Set; Codman) to expose the inferior clivus, anterior arch of C1, and C2 vertebral body. Closure was performed by approximating the 3 mucosal layers with 3-0 Vicryl interrupted sutures. In both procedures, the anterior arch of C1 and the odontoid process were removed using a high-speed drill and an ultrasonic surgical aspirator (Sonopet Ultrasonic Aspirator; Stryker). The transverse ligament, tectorial membrane, any residual ligaments, and tumoral tissue were removed decompressing the CVJ dura mater adequately. Contrast injection of metrizamide into the epidural space, fluoroscopy, and endoscopy served to verify and to complete decompression. Last, a second fluoroscopy was performed to gain the final confirmation.

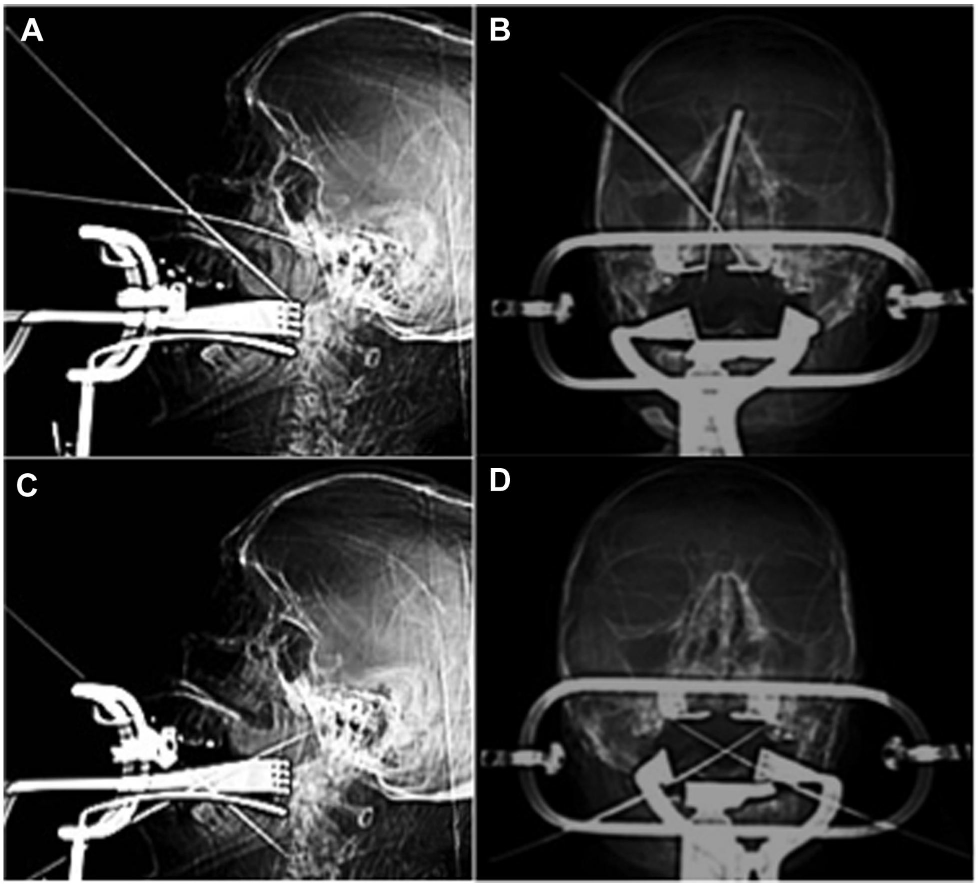

Figure 2. Lateral and anteroposterior open-mouth skull radiographs showing the inferred extension of the transnasal (**A**, **B**) comparing with transpolar (**C**, **D**) approach.

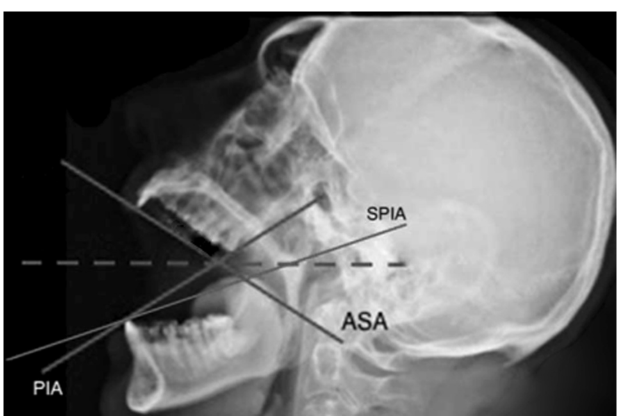

Figure 3. Lateral open mouth skull radiograph with the palatine inferior dental arch line (PIA), the line joining the superior dental arch and the anterior base of Atlas Superior dental Arch (ASA), and surgical PIA (SPIA). SPIA was found to engage at the soft palate at the line in the midsagittal plane that crosses in the midpoint. The radiologic PIA and ASA is defined as the line (*dotted line*) joining the superior dental arch and the anterior base of atlas.

Prophylactic antibiotics were administered intraoperatively and postoperatively (cefazolin, 2 g/day). Patients fixed in a halo vest were transferred to the intensive care unit, where they usually stayed for 48–72 hours.

A subsequent short occipitocervical instrumentation and fusion procedure was completed 1 week later according to our protocol for CVJ tumors and platybasia and to prevent cranial settling of the C2 vertebral body; we used a titanium implant (De-Puy Synthes Spine Mountaineer, California, USA) according to our patient's wishes. All the patients underwent magnetic resonance imaging and computed tomographic scans and standard and dynamic radiographic evaluation of the CVJ before and after surgery, immediately and every 6 months.

RESULTS

Experimental Study

The results of the experimental study are summarized in Tables 1, 2, 5, and 6. In all the patients, the angular gap between the radiologic and surgical lines was wider for the transnasal compared with the transoral approach. The most reliable

Table 3. Transoral Approach and Endoscopic Endonasal Approach: Pros and Cons

Approach	Advantages	Disadvantages
Transoral	Direct approach, radical removal of huge tumors, good visualization, and comfortable mobilization of surgical tools	Possible need of tracheostomy, need of feeding tube, difficult management of very high invagination conditions with platybasia
Transnasal	Partial isolation of the oral cavity, no need for tracheostomy, optimal control for clivus	Oblique approach, not recommended for large tumors and low-sited craniovertebral junction pathologies

radiologic preoperative line was found to be the PIA, with a mean ratio between the radiological PIA and surgical PIA of 0.82. The mean ratio between the radiologic and surgical NPL was only 0.66. In addition, the differences were statistically significant.

The transnasal surgical exposition was inferior compared with the transoral for the linear and angular surgical domain:

1) In the sagittal plane, from a minimum of 5.89% to a maximum of 76.48% (average 35.89%) as craniocaudal surgical exposition and from a minimum of 22% to a maximum of 77.42% as craniocaudal surgical angle.

2) In the coronal plane, from a minimum of 50.77% to a maximum of 83.88% (average 70.34%) as lateral surgical exposition and from a minimum of 65.58% to a maximum of 86.71% as lateral surgical angle (average 76.7%)

Clinical Study

Our recent institutional experience is summarized in **Tables 3** and **4**. Patient SO (number 1, harboring a huge CVJ progressive chordoma) underwent the operation in a staged way using both transoral and transnasal routes. All the patients but 1 were discharged after posterior instrumentation and fusion procedures within 2 weeks from the admission, and they improved or remained unchanged (in good neurologic status) after surgery and during the follow-up (**Figures 4** and **5**). Only patient 2 in the EEA group with an intraoperative cerebrospinal fluid (CSF) leak required immediate surgical repair with a mucosa pedicle flap, but 10 days later rapidly deteriorated and died 1 month after surgery. A meningoencephalitis confirmed with positive CSF cultures for fungi (*Candida albicans*) that, despite appropriate antimycotic therapy (Micafungin [5- fluorocytosine]), progressively worsened leading to the patient's fatal neurologic complications. On the other hand, no major complications occurred in the TOA group; patient 1 died from disease progression 88 months later, and patient 17 died from heart attack.

DISCUSSION

Experimental TOA and EEA: The History

In 2002, Alfieri et al.[8] performed a cadaveric study on exclusively transnasal endoscopic odontoidectomy through 1 or 2 nostrils, following Jho's[9] endonasal paraseptal technique. The line drawn between the eustachian tubes indicated the juncture between the clivus and atlas. The authors 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."[8] Three years later, Cavallo et al.[10] confirmed such an observation in cadaveric study. In 2007, Messina et al.[3] concluded that the EEA, like that TOA, could provide a direct route similar to the CVJ, but probably with less morbidity.[3]

In 2009, de Almeida et al.[2] introduced the NPL as a reliable predictor of the maximal extent of inferior dissection. Nevertheless, the radiologic NPL has routinely overestimated the lower limit of the endoscopic endonasal approach. The NAxL is supposed to predict more accurately the inferior limit of the endonasal approach to the CVJ, and it was proposed to be used easily in preoperative images to help the surgeon in the planning and choice of the right surgical approach.[2]

Among many experimental studies published so far, the last high-profile cadaveric study available in the literature on TOA is the one by Pillai et al.[11] This study quantifies the surgical volume gained by the following approach; the surgical area exposed over the posterior pharyngeal wall is significantly improved using the endoscope (606.5—127.4 mm^3) compared with the operating microscope (425.7—100.8 mm^3), without any compromise of surgical freedom ($P = 0.05$).[11]

Finally, in our recent articles, we confirmed a superior angular and linear domain for TOA compared with EEA.[5,12] Our studies suggest that, in normal conditions, the transnasal approach to the CVJ, as planned by the radiologic NPL, is a more oblique approach whose reliability is less predictable with classic preoperative radiological planning (NPL) compared with the transoral approach. In other words, both soft tissue lines (surgical) vary from hard tissue lines (radiologic), but NAxL more than surgical PIA.[5]

Surgical TOA and EEA: The History

The transoral approach has been used for years to drain retropharyngeal abscesses, but only in the 1930s was such an approach used to treat spinal abnormalities.[13] In 1962, Fang and Ong[14] published the first series of patients with irreducible atlantoaxial abnormalities treated with transoral decompression. The high morbidity and mortality caused poor acceptance of this approach to treat CVJ abnormalities. The microsurgical anterior approach to the CVJ, after being popularized by Crockard et al.,[15] has been widely described for decompression of irreducible extradural pathology. The use of the operating microscope, high-speed drill, self-retaining mouth retractors, flexible oral endotracheal tubes, intraoperative fluoroscopy, and electrophysiological monitoring has made this procedure much safer.[16] To improve visualization, splitting of the soft palate and even resection of the hard palate with extended maxillotomy are occasionally required. These procedures increase operating time and can result in significant postoperative morbidities such as velopharyngeal incompetence.[17] Menezes[18] started his experience with the transoral transpalatine approach in 1977, and up to 2008 there were 732 microsurgical procedures performed (280 children). According to him, the anterior transoral-transpalatine

Table 4. Transoral Approach Patients Characteristics

Patient	Age (years)	Sex	Primary Disease	Radiology	Preoperative C1-C2 Shift	Treatment	Postoperative Shift	Frankel Scale and Di Lorenzo Grade Changes	External Orthosis	Follow-Up (months)
1 SO	26	Female	CVJ chordoma	C0-C2 anterior compression CVJ instability	Virtual	1. Transoral decompression 2. C0-C3 reduction, lateral masses screws instrumentation and heterologous bone fusion	No	E/E I/I	Philadelphia (1 month)	88 (death for progression of disease)
2 FF	33	Male	CVJ chordoma	C0-C2 anterior compression CVJ instability	Virtual	1. Transoral decompression 2. C0-C3 reduction, C2 pedicles and C3 lateral masses screws instrumentation and heterologous bone fusion	No	E/E I/I	Philadelphia (1 month)	96
3 CO	68	Female	Rheumatoid arthritis	Anterior C1-C2 compression C1-C2 instability	>5 mm	1. Transoral decompression 2. C0-C2 pedicles and lateral masses screws instrumentation	No	D/E II/I	Soft collar (1 month)	79
4 CL	15	Male	Developmental anomaly C0-CI	C0-C1 anterior compression C1-C2 instability	>5 mm	1. Transoral decompression 2. CI laminectomy, C0 double vertical screws, C2 pedicles and C3 lateral masses screws instrumentation	No	D/E II/I	Soft collar (1 month)	74
5 CA	78	Male	Chordoma (chondroid)	CVJ instability C0-C2 anterior compression	Virtual	Transoral C1-odontoidecotmy and clivectomy C0 double vertical screws, C2 C3 C4 C5 lateral masses screws instrumentation	No	D/E II/I	Soft collar (1 month)	71
6 EA	11	Male	Impressio basilaris, Os odontoideum (Down syndrome)	C1-C2 anterior compression	Virtual, previously documented	Transoral C1-odontoidecotmy and clivectomy in C0-C2-C3 screwing instrumentation and heterologous bone fusion (previously implanted)	No	D/E II/I	Soft collar (1 month)	70
7 RR	14	Male	C2 fracture and dislocation	C2 fracture and C1-C2 dislocation with cervicomedullary contusion	>7 mm	1. Transoral C1-C2 decompression 2. C0-C3 C5 screwing instrumentation and heterologous bone fusion	No	D/E II/I	Soft collar (1 month)	67
8 MP	8	Male	Impressio basilaris	C0-C1-C2 compression	No	1. Transoral C1-C2 decompression 2. Staged C0-C2-C3 screwing instrumentation and fusion	No	D/E II/I	Halo vest plus Philadelphia (2 months)	63
9 LC	15	Male	Third condyle	C0-C1 compression	No	1. Transoral C0-C1 decompression 2. Staged C0-C2-C3 screwing instrumentation and fusion	No	D/E II/I	Halo vest plus Philadelphia (3 months)	100

CVJ, craniovertebral junction; ED, erniated disc.

Continues

Table 4. Continued

Patient	Age (years)	Sex	Primary Disease	Radiology	Preoperative C1-C2 Shift	Treatment	Postoperative Shift	Frankel Scale and Di Lorenzo Grade Changes	External Orthosis	Follow-Up (months)
10 CP	67	Female	Rheumatoid arthritis C2 fracture plus coronal and sagittal dislocation (2 cm)	C2 compression and myelopathy	Yes	1. C1-C2 decompression combined 2. C0-C2-C3 screwing instrumentation and fusion	No	C/E III/I	Philadelphia (2 months)	5
11 PP	50	Male	Basilar invagination	C2 anterior compression	Virtual	1. One-stage transoral decompression 2. C0-C3 instrumentation and fusion	No	D/E II/I	Soft collar (1 month)	12
12 SP	7	Male	Basilar invagination	C0-C1-C2 compression	Virtual	1. Transoral C0-C1-C2 decompression 2. C0-C2-C3 screwing instrumentation and fusion	No	D/E II/I	Soft collar (3 months)	65
13 SS	9	Male	Os odontoideum	C2 compression	Virtual	1. Transoral C1-C2 decompression 2. C0-C2-C3 screwing instrumentation and fusion	No	D/E II/I	Halo plus Philadelphia (2 months)	118
14 MM	68	Female	Rheumatoid artritis and ED C2-C3	C2-C3 compression	Virtual	1. Transoral C0-C1-C2 decompression 2. C0-C2-C3 screwing instrumentation and fusion	No	D/E II/I	Halo vest plus Philadelphia (3 months)	9
15 AE	12	Male	Basilar invagination plus ED C3-C4 myelopathy	C2 compression	Virtual	1. Transoral C0-C1-C2 decompression 2.Anterior C3- C4 discect. and titanium graft 3. C0-C2-C3 screwing instrumentation and fusion	No	D/E II/I	Halo vest plus Philadelphia (3 months)	3 (death from heart attack)
16 GC	23	Female	Impressio basilaris plus Chiari syndrome	C0-C1-C2 compression	Virtual	1. Transoral C0-C1-C2 decompression 2. C0-C2-C3 screwing instrumentation and fusion	No	II/I	Halo vest (3 months)	20
17 MS	50	Male	Impressio basilaris	C0-C1-C2 compression	Virtual	1. Transoral C0-C1-C2 decompression 2. C0-C2-C3 screwing instrumentation and fusion	No	II/I	Miami (2 months)	2

CVJ, craniovertebral junction; ED, erniated disc.

Table 5. Anterior Radiography: Craniocaudal Exposition and Surgical Angles—Comparison Between Transnasal and Transoral Approaches

Age (years)	Sex	Transoral Approach: Craniocaudal Exposition (cm)	Transoral Approach: Surgical Angle (degrees)	Transnasal Approach: Craniocaudal Exposition (cm)	Transnasal Approach: Surgical Angle (degrees)	Superiority of Transoral to Transnasal Craniocaudal Exposition (%)	Superiority of Transoral to Transnasal Surgical Angle (%)
75	Male	6.31	69	2.91	29	53.89	57.98
42	Male	6.07	50	4.65	39	23.46	22.00
51	Male	5.71	51	4.42	28	22.51	45.10
69	Female	4.25	45	1.00	14	76.48	68.89
55	Male	5.65	58	4.87	24	13.75	58.63
98	Female	6.75	63	5.40	32	20.00	49.21
79	Female	6.50	62	2.21	14	65.94	77.42
80	Male	5.79	60	5.45	30	5.89	50.00
56	Female	3.55	46	2.28	14	35.56	69.57
90	Female	6.17	45	4.58	22	25.72	51.12
69	Male	5.43	54	4.32	22	20.45	59.26
81	Male	6.11	43	5.26	27	13.92	37.11

approach has evolved into a safe, rapid, effective, and direct approach to the anterior irreducible pathology of the CVJ with minimal morbidity and mortality. Contrary to Menezes' experience, some studies claimed significant oropharyngeal morbidity from splitting the soft palate associated with the transoral approach. Jones et al.[19] reported that oropharyngeal complications occurred in 15.4% of patients who did not undergo splitting of the soft palate, as compared with 75% in the split soft palate group. The authors concluded that this procedure should be discontinued when it is not absolutely necessary.[19]

In 2005, Kassam et al.[1] operated on a 73- year old woman, affected by rheumatoid arthritis, resecting the odontoid with an

Table 6. Anterior Radiography: Axial Exposition and Surgical Angles—Comparison Between Transnasal and Transoral Approaches

Age (years)	Sex	Transoral Approach: Axial Exposition (cm)	Transoral Approach: Surgical Angle (degrees)	Transnasal Approach: Axial Exposition (cm)	Transnasal Approach: Surgical Angle (degrees)	Superiority of Transoral to Transnasal, Axial Exposition (%)	Superiority of Transoral to Transnasal, Surgical Angle (%)
75	Male	4.31	122	2.1	42	51.28	65.58
42	Male	6.533	158	1.133	21	82.66	86.71
51	Male	6.4	152	1.22	36	80.94	76.32
69	Female	4.55	140	2.24	39	50.77	72.15
55	Male	4.62	146	1.98	34	57.15	76.72
98	Female	6.866	138	1.544	40	77.52	71.02
79	Female	8.266	95	1.333	22	83.88	76.85
80	Male	4.930	124	1.533	26	68.91	79.04
56	Female	NP	NP	NP	NP	NP	NP
90	Female	NP	NP	NP	NP	NP	NP
69	Male	5.96	112	1.84	27	69.13	75.9
81	Male	6.43	135	2.03	30	68.43	77.88

NP, not performed.

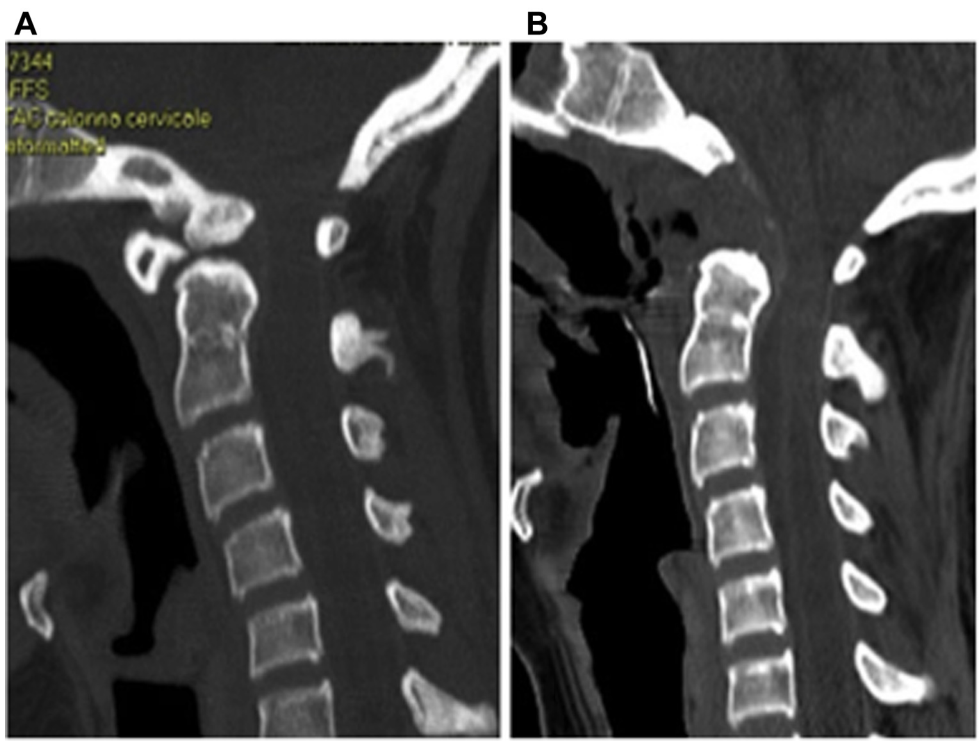

Figure 4. Pat # CL computed tomographic scan of a "third condyle" proatlas dysembriogenetic malformation (**A**) before and (**B**) after transoral endoscopic removal widely reaching the upper part (inferior third) of the craniovertebral junction without soft palate splitting.

EEA.[1] The author recognized that the TOA remains the "gold standard," but "the transnasal endoscopic approach being above the level of soft palate should expose to a lower degree of bacterial contamination." In fact, in the authors' opinion, an assumed less aggressive microbic flora in the nasal mucosa, compared with the oral one, should better protect by the risk of secondary infection.[1,10]

Furthermore, this approach was widely recommended as a valid alternative to the TOA for CVJ compressive pathologies to prevent the splitting of the palate, often required for adequate exposure in the TOA. In fact, palatal splitting has been reported to increase patient morbidity, especially velopharyngeal insufficiency, with subsequent escape of air and food into the nose during speech and swallowing, thus producing dysphonia and dysphagia.[3] Advantages and disadvantages of both techniques are summarized in Table 3.

It is important to point out that indications for performing anterior decompression (transoral or transnasal) are still a topic of discussion in some congenital malformations, such as type A basilar invagination, in which a fixed atlantoaxial dislocation is associated with a ventral brainstem compression. For patients in whom the instability of the atlantoaxial joint appears to be the primary cause of basilar invagination and therefore of brainstem compression, Goel and Shah[20,21] have supported the "posterior--only" strategy by means of atlantoaxial joint distraction and reduction of the basilar invagination, followed by fixation with lateral mass atlantoaxial plate and screw or, in selected cases, spiked spacer implants and bone graft without wire, screws, plates, or rods.

Present Experience

Among the 6 patients who underwent EEA, 5 of them had an uncomplicated postoperative course, and 1 patient developed an intraoperative CSF leak and subsequent meningitis and eventually died 5 weeks after surgery (Table 7); otherwise, no one of the TOA group had the same complication (Table 4). Such an event was probably due to the limitation of the bidimensional view with an oblique surgical view of EEA instead of the tridimensional transoral microsurgical view with a straightforward surgical view of TOA. Moreover, no possible other explanations (e.g., medical history, individual risk factors) could be given to better understand the unfavorable clinical course of the patient. There is no doubt that the transnasal endoscopic approach being above the level of soft palate should expose a lower degree of bacterial contamination[1]; nevertheless, differently from the other 5 patients, patient 1 experience an intraoperative complication (i.e., CSF fistula). The two-staged approach with halo vest immobilization for 1 week, along with unrecognized persisting CSF leakage, produced a delay of the identification of this

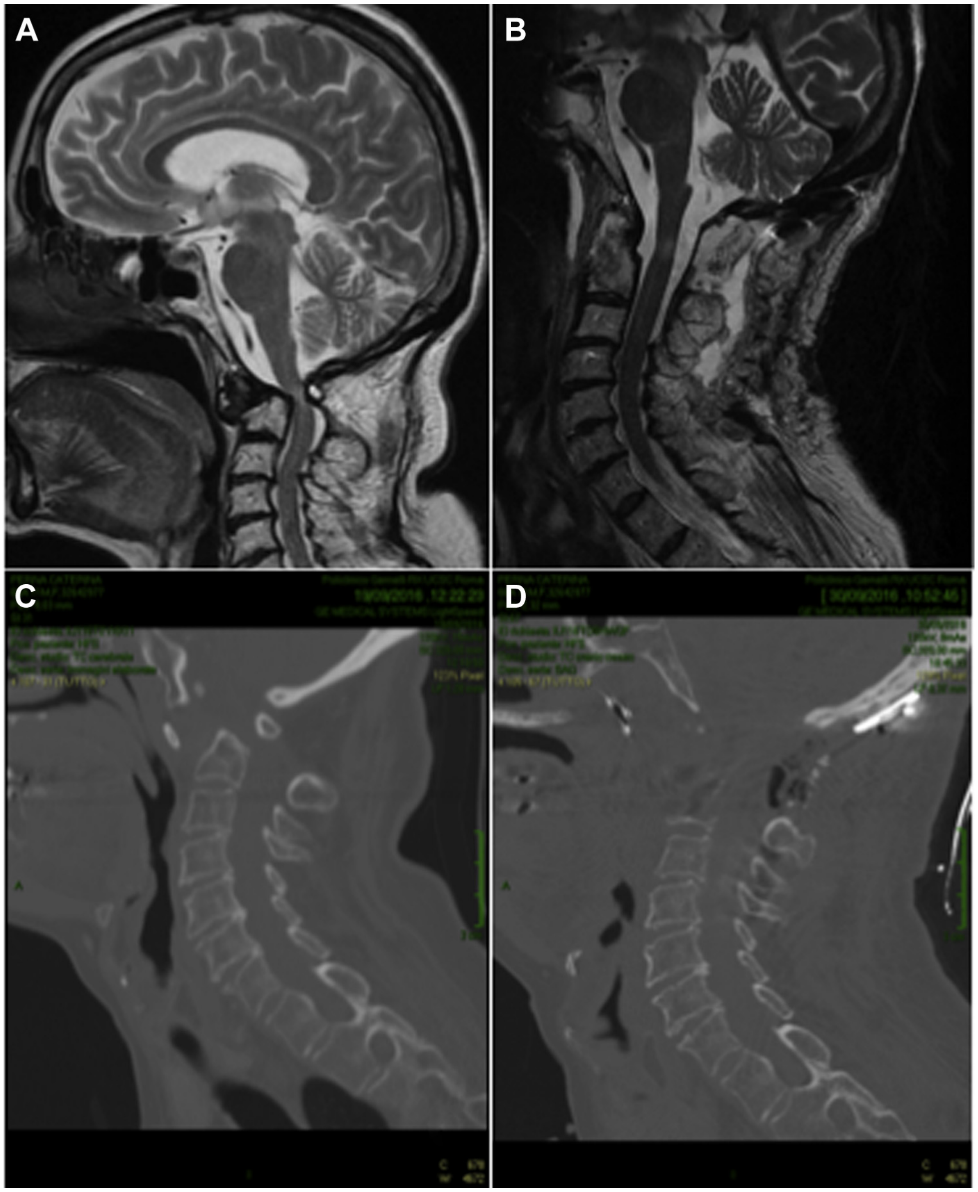

Figure 5. Pat # CP T2-weighted sagittal craniovertebral junction (CVJ) images preoperatively (**A**) and postoperatively (**B**); Sagittal computed tomographic images of the CVJ preoperatively (**C**) and after transoral decompression and posterior fusion (**D**).

complication and of the beginning of the medical (antibiotics) and surgical (external drainage) therapies.

Concerning a possible prophylactic antimycotic treatment, it does not seem reasonable for patients candidates for transmucosal surgical approaches to the CVJ because the literature does not provide any advice. Regarding what is available in the literature, antimycotic prophylaxis is suggested only for radiotherapy for patients with head and neck tumors and in patients harboring mucositis.[22,23]

A critical analysis of such a case allows the development of strategies that might decrease the risk of future patients developing such complications, although we will not be able to eliminate the risk.

The State of Art

According to the literature, 119 patients (including our 6) affected by CVJ disease and treated with EEA have been reported so far. Among these, a CSF leak (intraoperative, postoperative, or both)

Table 7. Endoscopic Endonasal Approach Patients Characteristics

Patient	Age (years)	Sex	Primary Disease	Radiology	Preoperative C1-C2 Shift	Treatment	Postoperative Shift	Frankel Scale and Di Lorenzo Grade Changes	External Orthosis	Follow-Up (months)
1 SO	35	Female	Chordoma	CVJ infiltration previously operated; 1) transoral and 2) C0-C3 reduction, lateral masses	Not performed	Transnasal decompression (0—30 degrees)	No	D/D I/I	Previously performed	36
2 FP	66	Female	Impressio basilaris	CVJ anterior compression	Yes	1. Transnasal decompression (0—30 degrees) 2. C0-C3 reduction, lateral masses screws instrumentation and heterologous bone fusion	No	D/E I/I	Halo vest (1 month)	3 (meningitis and death)
3 SR	47	Female	Impressio basilaris plus platybasia	CVJ anterior compression	Yes	1. Transnasal C1 decompression and odontoidectomy 2. C0-C3 reduction, C2 pedicles and C3 lateral masses screws instrumentation and autologous bone fusion	No	D/E I/I	Halo vest (1 month)	49
4 P LP	14	Female	Impressio basilaris plus platybasia	CVJ anterior compression	No	Transnasal C1 partial decompression and partial odontoidectomy	No	D/E I/I	No	51
5 NR	22	Male	Recurrence of clivus chordoma	CVJ destruction and compression	Not performed	1. Transnasal C1 decompression and odontoidectomy 2. C0-C3 reduction, lateral masses screws instrumentation and heterologous bone fusion	No	D/E I/I	Halo vest (1 month) and hard collar (2 months)	34
6 MG	58	Male	Myeloma	Odontoid infiltration	Not performed	Transnasal and odontoid biopsy	—	E/E I/I	No	27

CVJ, craniovertebral junction.

was reported in 13 patients (12.4%), a transient velopharyngeal incompetence variably associated with nasal speech and swallowing impairment was reported in 6 patients (5.6%), postoperative epistaxis was reported in 2 patients (1.86%), and respiratory dysfunction requiring a tracheostomy was reported in 2 of 107 patients (1.86%).[12] Moreover, a recent systematic review and meta-analysis,[22] showed a morbidity and mortality prevalence of EEA on TOA (mortality, 4%—2.9%; intraoperative CSF leaks, 30%—0.3%; postoperative CSF leak, 5.2%—0.8%; meningitis, 4%—0%; reoperation, 5.1%—2.5%; velopharyngeal insufficiency, 6.4%—3.3%; sepsis, 7.7%—1.9%) and a prevalence of TOA on EEA (arterial injury, 1.9%—0%; prolonged or reintubation, 5.6%—6.0%; wound infection, 3.3%—1.9%; tracheostomy, 10.8%—3.4%). Nevertheless, none of these differences were statistically significant except for postoperative thracheostomy.[24]

According to the literature and our personal experience, the presumed improved safety of EEA compared with the TOA should so require a reassessment,[25,26] though assessed worldwide as "minimally invasive."[27]

CONCLUSIONS

Experimental and clinical data suggest that there is no clear superiority of EEA over endoscopic TOA; however, EEA can produce complications similar to TOA in CVJ surgery, including velopharyngeal insufficiency and serious infections. Moreover, TOA offers a surgical freedom superior to EEA in normal anatomic conditions. More prospective trials need to be considered to compare the advantages and disadvantages of these different tools available in the modern armamentarium for this challenging and complex surgery.

REFERENCES

1. Kassam AB, Snyderman C, Gardner P, Carrau R, Spiro R. The expanded endonasal approach: a fully endoscopic transnasal approach and resection of the odontoid process: technical case report. *Neurosurgery*. 2005;57:E213.
2. de Almeida JR, Zanation AM, Snyderman CH, Carrau RL, Prevedello DM, Gardner PA, et al. Defining the nasopalatine line: the limit for endonasal surgery of the spine. *Laryngoscope*. 2009;119:239-244.
3. Messina A, Bruno MC, Decq P, Coste A, Cavallo LM, de Divitis E, et al. Pure endoscopic endonasal odontoidectomy: anatomical study. *Neurosurg Rev*. 2007;30:189-194.
4. Aldana PR, Naseri I, La Corte E. The naso-axial line: a new method of accurately predicting the inferior limit of the endoscopic endonasal approach to the craniovertebral junction. *Neurosurgery*. 2012;71(2 Suppl Operative):ons308-ons314 [discussion: ons314].
5. Visocchi M, Pappalardo G, Pileggi M, Signorelli F, Paludetti G, La Rocca G. Experimental endoscopic angular domains of transnasal and transoral routes to the craniovertebral junction light and shade. *Spine (Phila Pa 1976)*. 2016;41:669-677.
6. Visocchi M, La Rocca G, Della Pepa G, Stigliano E, Costantini A, Di Nardo F, et al. Anterior video-assisted approach to the craniovertebral junction: transnasal or transoral? A cadaveric study. *Acta Neurochir (Wien)*. 2014;156:285-292.
7. Shapiro S, Wilk MB, Chen HJ. A Comparative study of various tests for normality. *J Am Stat Assoc*. 1968;63:1343-1372.
8. Alfieri A, Jho HD, Tschabitscher M. Endoscopic endonasal approach to the ventral cranio-cervical junction: anatomical study. *Acta Neurochir*. 2002;144:219-225.
9. Jho HD. Endoscopy in skull base surgery. Proceedings of the 4th European Skull Base Congress, Nurnberg, Germany, May 19—22, 1999. *Skull Base Surg*. 1999;9(suppl 2):20-21
10. Cavallo LM, Messina A, Cappabianca P, Esposito F, de Divitiis E, Gardner P, et al. Endoscopic endonasal surgery of the midline skull base: anatomical study and clinical considerations. *Neurosurg Focus*. 2005;19:E2.
11. Pillai P, Sammet S, Ammirati M. Application accuracy of computed tomography-based, image-guided navigation of temporal bone. *Neurosurgery*. 2008;63:326-332.
12. Visocchi M, Signorelli F, Liao C, Rigante M, Paludetti G, Barbagallo G, et al. Endoscopic endonasal approach for craniovertebral junction pathologies: myth and truth in clinical series and personal experience. *World Neurosurg*. 2017;101:122-129.
13. Symonds C, Meadows S, Julian T. Compression of the spinal cord in the neighbourhood of the foramen magnum: with a note on the surgical approach. *Brain*. 1937;60:52-84.
14. Fang H, Ong G. Direct anterior approach to the upper cervical spine. *J Bone Joint Surg Am*. 1962;44:1588-1604.
15. Crockard HA. Ventral approaches to the upper cervical spine. *Orthopade*. 1991;20:140-146.
16. Pillai P, Baig MN, Karas CS, Ammirati M. Endoscopic image-guided transoral approach to the craniovertebral junction: an anatomic study comparing surgical exposure and surgical freedom obtained with the endoscope and the operating microscope. *Neurosurgery*. 2009;64:437-442.
17. Mummaneni PV, Haid RW. Transoral odontoidectomy. *Neurosurgery*. 2005;56:1045-1050.
18. Menezes AH. Surgical approaches: postoperative care and complications "transoral-transpalatopharyngeal approach to the craniocervical junction.". *Childs Nerv Syst*. 2008;24:1187-1193.
19. Jones DC, Hayter JP, Vaughan ED, Findlay GF. Oropharyngeal morbidity following transoral approaches to the upper cervical spine. *Int J Oral Maxillofac Surg*. 1998;27:295-298.
20. Goel A. Treatment of basilar invagination by atlantoaxial joint distraction and direct lateral mass fixation. *J Neurosurg Spine*. 2004;3:281-286.
21. Goel A, Shah A. Atlantoaxial joint distraction as a treatment for basilar invagination: A report of an experience with 11 cases. *Neurol India*. 2008;56:144-150.
22. Mücke R, Kaben U, Libera T, Knauerhase H, Ziegler PG, Hamann D, et al. Use of fluconazole as antimycotic prophylaxis in radiotherapy of patients with head and neck tumors. *Mycoses*. 1997;40(Suppl 1):53-55.
23. Bossi P, Numico G, De Santis V, Ruo Redda MG, Reali A, Belgioia L, et al. Prevention and treatment of oral mucositis in patients with head and neck cancer treated with (chemo) radiation: report of an Italian survey. *Support Care Cancer*. 2014;22:1889-1896.
24. Shiriver MF, Kshettry VR, Sindwani R, Woodard T, Benzel EC, Recinos PE. Transoral and transnasal odontoidectomy complications: a systematic review and meta-analysis. *Clin Neurol Neurosurg*. 2016;148:121-129.
25. Visocchi M, Barbagallo G, Pascali VL, Mattogno P, Signorelli F, Iacopino G, et al. Craniovertebral junction transanasal and transoral approaches: reconstruct the surgical pathways with soft or hard tissue endocipic lines? This is the question. *Acta Neurochir Suppl*. 2017;124:117-121.
26. Visocchi M, Germano' A, Umana G, Richiello A, Raudino G, Eldella AM, et al. Direct and oblique approaches to the craniovertebral junction: nuances of microsurgical and endoscope-assisted techniques along with a review of the literature. *Acta Neurochir Suppl*. 2017;124:107-116.
27. Zenga F, Pacca P, Tardivo V, Pennacchietti V, Garbossa D, Pecorari G, et al. Endoscopic endonasal approach to the odontoid pathologies. *World Neurosurg*. 2016;89:394-403.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 1 March 2017; accepted 4 May 2017

Citation: World Neurosurg. (2018) 110:592-603.
http://dx.doi.org/10.1016/j.wneu.2017.05.125

*Journal homepage: **www.WORLDNEUROSURGERY.org***

*Available online: **www.sciencedirect.com***