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SURGICAL TECHNIQUE

Transoral Approach for Odontoidectomy Efficacy and Safety

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Abstract
Background: Odontoid process pathologies can cause upper motor neuron lesions. These pathologies can be approached through either a high retropharyngeal approach or a transoral approach. The introduction of the surgical microscope, proper instrumentations, and proper antibiotics has increased utilization of the transoral approach. *Questions/Purposes:* Our approach to anterior odontoid resection through transoral approach for different pathologies resulting in compression the cervical cord or causing craniocervical instability is described here. We aim to explore the safety and efficacy of this approach. *Methods:* Twenty cases of different odontoid pathologies were managed by transoral surgery. Patients were assessed clinically for axial neck pain and radicular symptoms using visual analog scale. The Nurick score was used to get an overall functional evaluation of the difficulty of ambulation and walking. Radiological evaluation of the patients included plain radiographs, CT scans, and MRI of the cervical spine. Posterior surgery was done as a first stage for restoring the sagittal profile of the cervical spine. Transoral surgery was done as a second stage for odontoid resection and anterior decompression of the cord. *Results:* Average follow-up was 29.4 ± 3.8 months. Mean preoperative Nurick scale was 1.3 ± 1.2. Mean postoperative Nurcik scale was 0.5 ± 0.61. Patients with axial neck pain were improved after surgery except the 6 patients; mean VAS preoperative 8.2 ± 2.3 SD, mean postoperative VAS 3.7 ± 0.8SD, and radicular symptoms were not significantly changed after surgery; gait changes were improved in all patients with preoperative gait disturbance. *Conclusion:* The transoral approach is a safe and effective surgical method for the direct decompression of ventral midline extradural compressive disease of the craniovertebral junction.

Keywords craniocervical instability · odontoidectomy · transoral approach

Introduction

Odontoid process pathologies can cause upper motor neuron lesion either through direct anterior compression or by causing craniocervical instability. These pathologies can be approached through either a high retropharyngeal approach or transoral approach. The introduction of the surgical microscope, proper instrumentation, oral retractors, and proper antibiotics has popularized the transoral approach, which is described as a direct approach to the anterior aspect of the odontoid process [2, 4, 10–12, 22, 27, 28, 35, 36].

The transoral approach is described to manage different odontoid pathologies; in 1919, it was first described by Kanavel to remove a bullet entrapped between skull base and C1 [20], it was successively described by Scoville and Sherman in 1951 for odontoid process resection in basilar impression [33]. Southwick, Robinson, Mosberg, and Lippman described the transoral approach for managing lesions of the second cervical vertebra [29, 32]. Fang and Ong in 1962 used the transoral approach in the management of six patients with traumatic Cl–C2 instability and tuberculosis of the upper cervical spine [15].

This report presents our technique for using the transoral approach. Our purpose is to report our initial experience with this technique with emphasis on our experience of the efficacy and safety of anterior odontoid resection through transoral approach for different pathologies compressing the cord or causing craniocervical instability.

Level of Evidence: Therapeutic Study Level IV

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Patients and Methods

In a period extending from March 2012 to January 2016, 20 cases of different odontoid pathologies were managed by transoral surgery. Of the 20 patients managed by transoral odontoid resection, seven patients were females and 13 males. Mean age was 37.2 years ± SD 13.78 (range 16–62). Follow-up was 29.4 ± 3.8 months (range 24–39). Nine patients were presented by craniocervical instability that required craniocervical posterior fixation as a first-stage surgery; three patients presented with non-united odontoid fracture, three patients with odontoid infections, two patients with odontoid neoplasms, and a case of os odontoideum (Table 1).

Patients were assessed clinically for axial neck pain and radicular symptoms using the visual analog scale (VAS). The Nurick score was used to get an overall functional evaluation of the difficulty of ambulation and walking. Mean preoperative Nurick scale was 1.3 ± 1.2 (range 0–4); seven patients were presented without any signs of cord compression, six patients with upper motor neuronal lesion (UMNL) without difficulty in walking, three patients were having minimal difficulty in waking, and two patients with marked limitation of walking. Two patients needed walking aids. At 2-year follow-up, reassessment is done by VAS and Nurick scales.

Radiological evaluation of the patients included plain radiographs of the cervical spine in AP and lateral projections with dynamic views to detect any craniocervical instability. CT scans were routinely done evaluating the extent of bone destruction of the odontoid and anterior C1 arch, also it is a more accurate and easier evaluation of the craniocervical stability using Power's ratio [14]. MRI evaluates the integrity of ligaments, soft tissue extension of tumors, and infection, and detects any cord compromise.

Following careful evaluation of patients, surgical decision was determined. Posterior surgery was done as a first stage for restoring the sagittal profile of the cervical spine and stabilizing either the craniocervical junction by occipitocervical fusion or by C1–C2 fixation according to the involvement of C1 arch and C2 ligamentous complex.

Transoral surgery was done as a second-stage anterior surgery; the two stages were done within 1 week according to patient general condition; fundamental prerequisite for transoral surgery is the patient's ability to open his mouth 25 mm or more to gain access to posterior pharynx [5].

Preoperative Preparations

The chance of post-operative infection is not considerably higher than that of high retropharyngeal approach [13, 26]. Preparation of oral cavity was done before surgery by taking bacteriologic swabs to detect and manage any oral infections. Aqueous mouth washes and cetavlon solution were used and mixed with local acting antibiotics. Systemic antibiotics (cephalosporin and metronidazole) were given and continued for 2 days postoperatively. Lastly, to avoid oral swelling, 1% hydrocortisone ointment was used perioperatively. Topical hydrocortisone ointment was applied to tongue, lips, and mouth cavity. This was done prior

Table 1 Shows the clinical features, demographic data and the pre and postoperative Nurick scale

Patient	Gender	Age (years)	Pathology	Preoperative Nurick scale	Level of fixation	Postoperative Nurick scale	Follow-up (months)
1	F	22	Rheumatoid	0	C1–C2	0	28
2	M	16	Os odontoideum	2	C0–C1–C2	1	25
3	M	30	Aneurysmal bone cyst bone cyst	0	C0–C2–C3	0	26
4	F	24	Rheumatoid	1	C1–C2	0	32
5	M	51	Odontoid fracture	3	C0–C1–C2	1	26
6	M	42	Odontoid fracture	0	C0–C1–C2	0	29
7	M	33	Odontoid fracture	3	C1–C2	0	30
8	F	23	Rheumatoid	2	C1–C2	0	36
9	M	62	Infection	1	C0–C1–C2-C3	2	34
10	F	34	Odontoid fracture	1	C0–C1–C2	1	29
11	M	43	Rheumatoid	0	C1–C2	0	33
12	M	36	Rheumatoid	4	C1–C2	1	31
13	M	27	Chordoma	4	C0–C2–C3–C4	1	24
14	F	55	Infection	1	C0–C1–C2–C3	1	28
15	F	42	Rheumatoid	0	C1–C2	0	31
16	F	31	Rheumatoid	0	C1–C2	0	26
17	M	27	Rheumatoid	2	C1–C2	0	39
18	M	58	Infection	0	C0–C1–C2	0	28
19	M	60	Infection	1	C1–C2	1	25
20	M	29	Osteoblastoma	1	C1–C2	1	28

The P value is .009976. The result is significant at $p < .05$
- Age mean 37.25 years (± SD 13.78) range 16–62
- Preop nurick 1.3 ± 1.2 (0–4)
- Postop nurick 0.5 ± 0.61 (0–2)
- Follow-up 29.4 ± 3.8 months (24–39)

to the procedure and repeated again at the end of the surgery. Topical steroid application has been shown to be more effective than I.V. administration for prevention of this local swelling [13].

Anesthesia

All cases were anesthetized using nasotracheal intubation with cuffed endotracheal tube. The tube was retracted laterally with one of the blades of the Crockard retractor. Tracheotomy is not routinely used in transoral approach; it is needed in less than 15% of cases but is possibly indicated for patients in which long-term ventilation problems are anticipated and in cases of extended maxillotomy [9, 19].

Surgical Technique

The patient was positioned supine position on the operating table with the head slightly elevated compared to the feet and held in the Mayfield head holder. Transoral retractor (Crockard™ Transoral Instrument Set, Codman, Johnson and Johnson) was applied and gradual retraction of upper and lower jaws was done. The tongue is retracted downward, and careful examination of the oral cavity is done to avoid pressure over the tongue or pressing the tongue against the teeth. Placing some form of packing under the handle of the tongue blade may help to prevent slipping of transoral retractor.

The tubercle of C1 was localized by palpating it using dissector; then, local infiltration with lignocaine and 1:200,000 adrenaline was done. The posterior pharyngeal wall is incised vertically at the midline starting just below the level of the uvula downward; the incision is 3-cm long centered over C1 tubercle. The incision is undermined to develop flaps where the pharyngeal retractor is placed; monopolar cautery is used to incise through the longus coli and the attachment of the anterior longitudinal ligament; this will expose the anterior arch of C1 and the odontoid process.

To continue the exposure of the odontoid process, a sufficient part of the anterior C1 arch maybe resected using high-speed drill, according to Bouramas D and Crockard A. We used curettes and periosteal elevators to outline the anterior arch of C1, the base of odontoid process, and C2 vertebral body. The inferior one third to two thirds of the anterior C1 arch is resected to uncover the base of odontoid process by means of a high-speed drill and Kerrison rongeurs. We made an effort to limit the resection of the anterior C1 arch to reserve the structural integrity of the C1 ring. Also, the anterior C1 tubercle denotes a key radiographic milestone in patients with C1–2 instability. Yet, enough bone must be resected to expose the dens sufficiently, and if needed, a complete removal of the anterior C1 arch should be performed. Odontoid resection can be done while preserving C1 arch [13]. C1 arch resection was only done in five cases in our series.

After exposure of the odontoid process, gradual decancellation of the process with curettes and high-speed drill is done till it is totally hollowed or thinned out. This is done under microscopic guidance. The remaining cortical shell of the odontoid is removed using Kerrison Rongeurs taking 1–2-mm bites till the dura is exposed with brisk pulsations. In order to achieve adequate decompression, the ligaments and the tectorial membrane were excised. In infections and tumors, removal of infected tissues and tumor was done using Rongeurs. This approach can be extended down to C2–C3 disc space, and the disc can be removed and prepared for reconstruction and grafting. At this stage, the vertebral artery should be avoided by avoiding lateral dissection of more than 10 mm from midline. Autologous iliac bone graft is impacted between the arch of C1 and remaining part of C2 body or C3 after excising and preparing the disc for fusion. Closure was performed in two layers: muscular and mucosal, with Vicryl 3.0 continuous stitches.

Postoperative Care

Great care should be taken with the mouth and the nose; 1% hydrocortisone is applied at the end of the procedure and every 6 h for the first 2 days. The endotracheal tube is removed after a lateral cervical X-ray has confirmed the absence of posterior pharyngeal swelling. A nasogastric or pharyngogastric tube is in place for 5 days. Enteral nutrition by the indwelling feeding tube is started on postoperative day 1 and continued for 3 to 5 days. The patient's diet is gradually advanced from liquids to soft regular foods and then to regular foods, usually within 14 days. Antibiotics are administered for 2 days in the absence of bacterial infection. Chest physiotherapy and mobilization are very important.

Results

The mean preoperative Nurick scale of 1.3 ± 1.2 (range 0–4) was improved to a mean postoperative Nurcik scale of 0.5 ± 0.61 (range 0–2) ($P = 0.001$) (Table 1).

Fourteen of the 20 patients with axial neck pain were improved after surgery. Four assessed the pain to be the same while two patients deteriorated following surgery. Mean VAS preoperative of 8.2 ± 2.3 SD was decreased to a mean postoperative VAS 3.7 ± 0.8SD ($p < 0.0001$). Radicular symptoms were not significantly changed after surgery. We believe this may be explained by the presence of coexisting subaxial foraminal stenosis. There was no cranial nerve involvement in any case. Gait changes were improved in all patients with preoperative gait disturbance (seven cases) (Table 2).

Table 2 Shows the postoperative evaluation of patients

		Same	Improved	Worse
Neck pain	20	4	14	2
Myelopathy	13 (65%)	2	11	–
Gait disturbance	7 (35%)	–	7	–
Radiculopathy	18	16	2	–
Cranial nerves	–	–	–	–

Mean operative time for transoral surgery was 170 min; mean blood loss was 270 ml.

Mortality directly related to surgery did not happen; intra-operative complication, one patient had CSF leak, and a leakage in the dura mater was noticed and managed throughout the surgery using dural patching, careful pharyngeal wound closure, and placement of a lumbar drain; post-operative systemic complications followed: one patient had pulmonary infection.

Discussion

Transoral odontoid resection is a direct technique for ventral decompression of the spinal cord in cases of non-reducible subluxation following odontoid fractures, odontoid pathologies such as odontoid neoplasms and infections. Rheumatoid disorders causing basilar invagination can also be treated by anterior decompression using the transoral approach [8]. This surgical intervention requires practice cooperation between the surgical and anesthetic teams in order to provide optimal results.

Anterior approach influences directly the place of the lesion and therefore decompresses the cervicomedullary junction remaining away from laterally located neurovascular structures [3, 18, 30, 31, 34]. Moreover, advanced understanding of the craniocervical dynamics and new techniques to determine the place of impingement leads to assumption that the transoral approach, with adding the exact type of stabilization, is the gold standard in the management of pathologies, creating irreducible anterior compression of the cervicomedullary segment [6, 7, 26, 28]. As well lateral approaches are feasible but they need a wide dissection, risk of damage of the vertebral artery, of the jugular bulb, and of the hypoglossal nerve and we favor to reserve them to enormous tumor masses involving lateral structures [1, 31, 37, 38].

Transoral approach is controversial at many points. Is it better to use tracheostomy or nasotracheal intubation? Is it sufficient for exposure to retract or incise the soft palate and the use of multilayer or single layer closure of the incision? In our study, we used nasotracheal intubation in all cases. Menezes believe that soft palate incision is only needed in cases were exposure of the clivus is needed as in cases with marked proximal migration of the odontoid in basilar invagination [23, 24]. In our experience, this was needed in one case with rheumatoid arthritis with limited mandibular excursion. Predicting the requirement of soft palate incision rather than just retraction can be done by using CT scan of the patient to identify the relationship between the odontoid and the soft and hard palate. This relation is markedly affected by the degree of subluxation and vertical migration of the odontoid. In the current study, the posterior pharyngeal wall was closed in double layer while the soft palate was closed in three layers (single case); this was based on the recommendation reported by Crockard and Johnston [9].

There was a great concern about infection after transoral approach; early reports about this approach demonstrated infection rate approximating 50% (fang) [15]; however, Sonntag et al. in a series of 29 patients treated over 10 years reported no infections [17]; Crockard et al. managed 22 patients with rheumatoid disease by transoral odontoid resection without reported wound infection. This may be explained by better preoperative preparation and antibiotic coverage [8]. In the current study, there was no wound infection. Wound infections should be treated using broad-spectrum antibiotics till culture sensitivities are presented. Wound dehiscence at any time needs reoperation and reclosure. Furthermore, wound dehiscence taking place after the first week should increase the doubt of a likely underlying retropharyngeal infection or abscess.

In this series of 20 patients with odontoid, pathologies were quite varied as patients presented with myelopathy, neck pain, gait changes, and radiculopathy. Cases presenting with mild myelopathy who could walk (Nurick 0, I, and II) had a better recovery than those with advanced myelopathy. Patients with axial neck pain were improved after surgery except for six patients, four of whom had unchanged pain scores while two patients deteriorated following surgery. This can be explained by the presence of painful subaxial facet arthritis. Radicular symptoms were not significantly changed after surgery which may be explained by the presence of coexisting subaxial foraminal stenosis. Neurological weakening after transoral surgery is uncommon. Patients with new neurological deficits should be evaluated for a loss of spinal alignment, persistent cervicomedullary compression, epidural hematoma, epidural abscess, meningitis, or vertebrobasilar occlusion [21].

Medical complications, including chest infection, deep venous thrombosis, pulmonary emboli, and myocardial infarctions, are common following transoral surgery, chiefly in patients with severe preoperative neurological deficits or devastating medical illnesses. Consequently, it is important to adjust the patient's overall medical condition before surgery and use a prophylactic measures against deep venous thrombosis during and after surgery. Postoperatively, chest physiotherapy should be aggressive and early mobilization after stabilization to avoid these complications [21].

CSF leakage denotes a significant risk to the patient and should be punctually addressed. Suitable treatment includes dural patching, careful pharyngeal wound closure, and placement of a lumbar drain. If a CSF leak halts with lumbar drainage but returns after the drain has been closed or discontinued, then the patient needs a lumboperitoneal shunt. If persistent CSF leak occurs despite lumboperitoneal drainage, then reoperation and dural patching are required. Postoperative meningitis should increase the thought of a CSF leak. Appropriate treatment comprises intravenous antibiotics and placement of a lumbar drain [25]. In our study, no CSF leakage is encountered postoperatively.

The transnasal fully endoscopic technique, owing to its reduced invasiveness, may denote an interesting substitute to transoral approach for removal of odontoid process in patients with bulbo-medullary compression. Yet, it should be noted that there are some restrictions in this approach. Nevertheless, the learning curve, the lesion must be situated almost in the midline and above the "nasopalatine line,"

and sometimes, a partial posterior drilling of the hard palate is required to gain a more caudal access [16].

We admit that our study has no control group, and there are variable pathologies involved in the pathogenesis but all patients had irreducible midline extradural lesion that compresses the cervicomedullary junction. We aimed at our study to investigate the safety of this technique and its ability to achieve adequate decompression to relief myelopathy.

In conclusion, the transoral approach is an active surgical technique for the direct decompression of ventral midline extradural compressive disease of the craniovertebral junction. This manuscript describes odontoidectomy with this approach. The introduction of surgical microscope, proper instrumentations, oral low-profile retractors and proper antibiotics, contemporary microsurgical dissection and dural closure techniques, and meticulous perioperative radiographic assessment of spinal stability minimalize perioperative complications and simplify good long-term outcomes.

Compliance with Ethical Standards

Conflict of Interest: Ahmed Mohamed Elbadrawi, MD, and Tameem Mohamed Elkhateeb, MD, have declared that they have no conflict of interest.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was obtained from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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