Endoscopic Transnasal Surgery as a Replacement for Maxillotomy Techniques to Approach the Central Skull Base: Fewer Complications and More Acceptable to Patients?

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Abstract

Objectives To compare the complication rates of endoscopic transnasal and open maxillotomy approaches for the central skull base.

Design Retrospective review.

Setting Single-center study, London, United Kingdom.

Participants From 1992 to 2012, 81 patients underwent surgery for skull base lesions, 59 by maxillotomy and 22 by endoscopy.

Main Outcome Measures Total time of surgical anesthesia, blood loss, complications, duration of tracheal intubation, duration of hospital stay, myelopathy score, and mortality rate.

Results The surgical time, blood loss, and duration of the postoperative intubation period were significantly less with endoscopy ($p < 0.001$). Requirements for intensive care, ward stay, and total hospital stay were also significantly less in the endoscopic group ($p = 0.01$, $p < 0.001$, and $p < 0.001$, respectively). The complication rate was lower with transnasal endoscopic surgery.

Conclusion In patients for whom open maxillotomy or endoscopic surgery are both feasible, the preference should be to perform endoscopic surgery, with better visualization and fewer complications.

Keywords
- maxillotomy
- endoscopy
- skull base
- surgery
- complications

Introduction

Surgery for ventral midline skull base pathologies is challenging due to the central location and surrounding structures that make access difficult. Open surgical approaches include extended lateral, posterolateral, anterior subfrontal, transglabellar, and pterional or lateral transtemporal routes.[1–6] However, purely midline pathology is best approached via the midline, and for this purpose the standard transoral operation was developed to include a maxillotomy,[7–11] thereby allowing more superior exposure as far as the pituitary fossa (►**Fig. 1**).

This so-called open-door maxillotomy became the mainstay of surgery for clivus chordomas and basilar impression from rheumatoid disease and congenital syndromes[9,10,12] and was a very effective technique that avoided transgressing the planes of cranial nerves and arteries. A modified

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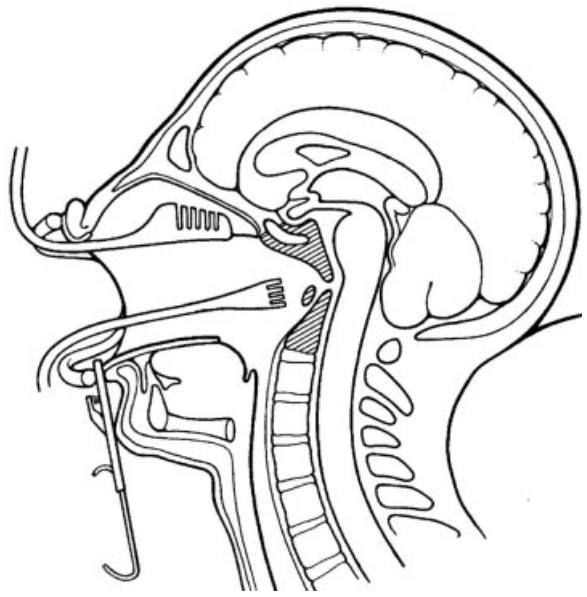

Fig. 1 Schematic diagram of the possible surgical exposure via an open-door maxillotomy.

transfacial approach provides similar access but requires rotation of the nose on a pedicle flap.[4] These approaches are technically demanding and require experience in maxillofacial techniques, and they can be rather time consuming.

Over the past decade, endoscopic techniques for sinus surgery have developed to include approaches to the anterior skull base and intracranial compartments.[13–18] Endoscopic surgery is potentially quicker and more acceptable to patients. Although short-term results are encouraging, the long-term results are awaited.

The endoscopic transnasal approach has a steep learning curve and increased risk of cerebrospinal fluid (CSF) leakage, but advances in the technique and a team approach between neurosurgeons and otolaryngologists have decreased the potential risks.[18] Major advantages of the endoscopic approach are better visualization of structures and a direct approach without the need for brain retraction.

This study compared the complication rates of the endoscopic transnasal approach and maxillotomy techniques performed in a single center. In the past decade, there has been a step change from maxillotomy techniques to the use of endoscopic transnasal surgery, and we present our early experience.

Material and Methods

A retrospective review of medical records of consecutive patients who underwent surgery for skull base lesions in our institution was performed including surgery by endoscopic transnasal approach or maxillotomy techniques between 1992 and 2012. Demographic and clinical information was studied including the diagnosis, preoperative tumor volume, surgical approach, surgical time, intraoperative blood loss, complications, duration of postoperative intubated days, length of postoperative stay in the intensive care unit (ICU) and total hospital stay, need for supplemental feeding by nasogastric or percutaneous endoscopic gastrostomy (PEG), whether craniocervical junction fixation was performed, pre- and postoperative Ranawat myelopathy score, and mortality rate. Patients were regularly followed in the outpatient clinic at serial intervals, and the need for further surgical procedures either due to a complication or due to progression of the disease was documented.

The Student *t* test was used to identify the statistical differences in parameters and outcomes. Complication rates were compared using the chi-square test. The p values < 0.05 were considered statistically significant.

Surgical Technique

Open-Door Maxillotomy

This technique was described previously,[19] but in brief, an incision is made above the superior gingival line. The face is degloved superiorly as far as the infraorbital neurovascular bundle and external nares, and a Le Fort I osteotomy is performed. The maxilla is then divided in the midline with an oscillating sagittal saw, and the resultant halves of the maxilla are swung laterally to provide midline exposure of the posterior nasopharynx (►**Fig. 2**).

The pharyngeal mucosa is divided either by an inverted U-shaped flap, or a vertical midline incision. The longus colli and longus capitis muscles are divided in the midline and retracted using custom-made self-retaining retractors (Crockard instruments, Codman). The skull base may be exposed from the sphenoid sinus above, to the C2 vertebral body below.

Endoscopic Transnasal Surgery

For technical details, see Stippler et al and Kassam et al.[18,20,21] Patients were deemed suitable for treatment depending on the anatomy and nature of the surgical target, surgical goals, and review of magnetic resonance imaging (MRI) and computed tomography imaging of lesions, in particular, the position of the hard palate and the degree of lateral extension of the pathology. Neuronavigation (Stealth, Medtronic) was used in most cases. We used a standard zero-degree rigid endoscope and a bimanual binasal technique to approach the sphenoid sinus and clivus. This necessitates opening the posterior nasal septum to allow for a "four-instrument" technique, and lateralization of the middle turbinates. Unlike Kassam et al,[20] we do not routinely remove the middle turbinate but outfracture them, displacing the turbinates laterally. For greater exposure, a medial maxillary sinus fenestration may be performed to allow more space for lateralization of the middle turbinate.

Results

A total of 81 patients underwent surgery for skull base lesions by maxillotomy or endoscopic techniques. In those who underwent maxillotomy, 59 patients underwent a total of 65 procedures. The male-to-female ratio was 28:31. A total of

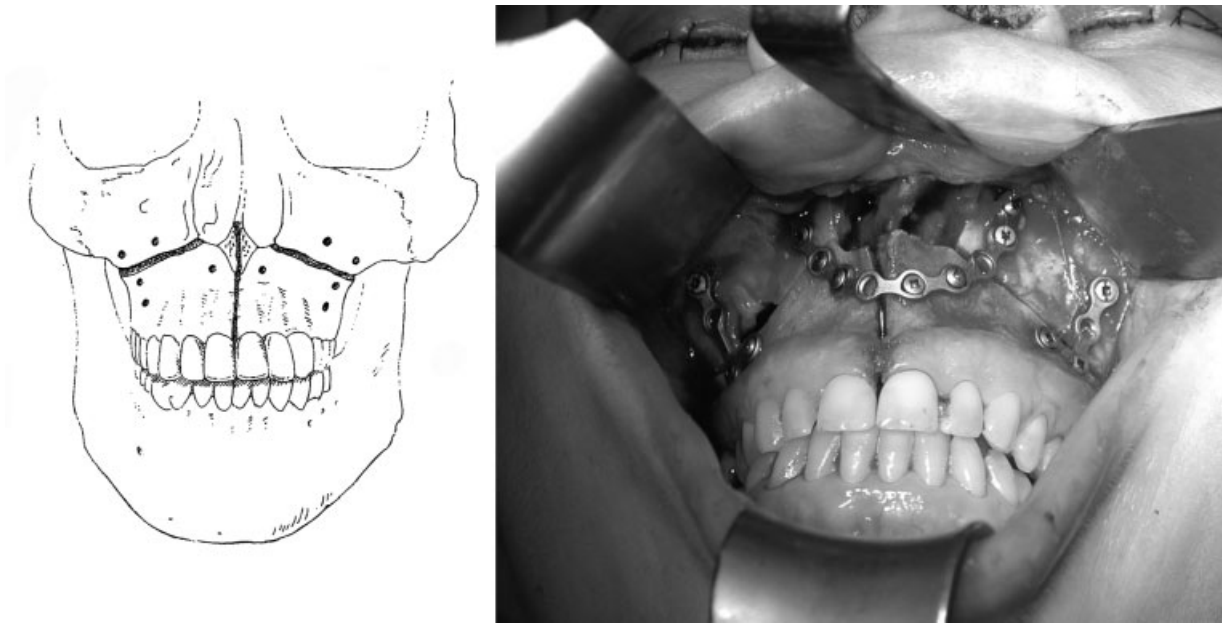

Fig. 2 Diagram of saw cuts for an open-door maxillotomy, and illustration of plates in situ after reconstruction of the maxilla.

58 open-door maxillotomies, 6 midface degloving approaches, and 1 Le Fort type 1 osteotomy were performed. The mean age at operation was 39 years old (standard deviation [SD]: 16). Diagnoses are specified in ►**Table 1**.

Preoperative tumor volumes were estimated from the MRI scans, calculated using the formula "A × B × C/2" where A, B, and C were the maximum dimensions of the tumor measured on the scans, divided by 2, to estimate volume of a sphere. In the endoscopic surgery group, the mean tumor volume was 53.6 cc, standard error was 4.3 cc. In the maxillotomy group, mean was 56.6 cc, standard error was 5.1 cc. There was no significant difference in the tumor volume before surgery in the endoscopic and maxillotomy groups ($p = 0.65$).

A total of 23 operations involved simultaneous occipitocervical fixation to stabilize the craniocervical junction. The mean anesthetic time, from induction to recovery, was 338 minutes (SD: 163 minutes), and mean blood loss was 1695 mL (SD: 1923 mL). Patients were intubated by tracheostomy for a mean period of 20 days after surgery (SD: 39 days). Average length of stay in the ICU was 8 days (SD: 19 days), on the ward was 29 days (SD: 38 days), and total hospital stay was 44 days (SD: 76 days). Patients undergoing maxillotomy required nasogastric or PEG feeding for a mean of 24 days (SD: 41 days). ►**Table 2** summarizes the differences between maxillotomy and endoscopy.

Neurologic function (Ranawat myelopathy grade) remained the same following surgery in 56 procedures, was improved after 4 procedures, and deteriorated after 5 procedures. However, a greater percentage of patients undergoing maxillotomy were myelopathic (30.5%) compared with the endoscopy group (11.1%) before surgery. A total of 29 of the 65 procedures had at least one complication with a complication rate of 44.6% (►**Table 3**). There were six deaths within 30 days from surgery.

In the endoscopic group, there were 22 patients, including 13 men and 9 women, and a total of 26 procedures. Their mean age at operation was 41 years (SD: 18 years). Diagnoses are shown in ►**Table 1**. Two patients required simultaneous occipitocervical fixation. The mean anesthetic time was 173 minutes (SD: 109 minutes), and the mean blood loss was 438 mL (SD: 200 mL). Patients were intubated postoperatively for a mean of 1 day (SD: 1 day). Intubation < 24 hours was recorded as 1 day's duration. Average length of stay in ICU after surgery was 1 day (SD: 2 days), ward stay was 8 days (SD: 6 days), and total hospital stay was 9 days (SD: 8 days). Nasogastric feeding was not required in any patient. The neurologic function according to Ranawat grading remained unchanged after all endoscopic procedures. There were complications in 3 of the 26 procedures (►**Table 3**). There were no deaths within 30 days of surgery. Mean follow-up was 18 months (SD: 16 months).

Table 1 Diagnoses of patients undergoing surgery for maxillotomy and endoscopic groups

Diagnosis	Maxillotomy	Endoscopy
Chordoma	32	11
Other malignant tumor	3	3
Benign tumor	3	4
Congenital basilar impression	20	4
Rheumatoid basilar invagination	1	0
Infection/other	6	4

Table 2 Comparison of maxillotomy and endoscopic surgeries

	Maxillotomy (65 procedures)	Endoscopy (26 procedures)	Significance
Mean age, y (SE)	39 (1.9)	41 (3.5)	$p = 0.68$
Anesthetic time, min (SE)	338 (20.2)	173 (21.4)	$p < 0.001$
Blood loss, mL (SE)	1695 (238.5)	438 (39.2)	$p < 0.001$
Intubation, days (SE)	20 (4.8)	1 (0.2)	$p < 0.001$
Intensive care unit stay, d (SE)	8 (2.4)	1 (0.4)	$p = 0.01$
Ward stay, d (SE)	29 (4.7)	8 (1.2)	$p < 0.001$
Supplementary feeding, d (SE)	24 (5.1)	0	$p < 0.001$

Abbreviation: SE, standard error.

Comparison between the maxillotomy and endoscopy groups demonstrated similar ages and durations of preoperative symptoms ($p = 0.6$, $p = 1$, respectively). The intraoperative surgical time, blood loss, and duration of postoperative intubation period was significantly less with endoscopy ($p < 0.001$, $p < 0.001$, and $p < 0.001$, respectively). Duration of ICU stay, ward stay, and total hospital stay were also significantly less in the endoscopic group ($p = 0.01$, $p < 0.001$, and $p < 0.001$, respectively). The morbidity rate and the mortality rate were significantly lower after transnasal endoscopic surgery (►**Fig. 3**).

In the maxillotomy group, patients had longer follow-up compared with the more recent endoscopic series (mean follow-up of 128 months for maxillotomy and 18 months for endoscopic surgeries; $p < 0.001$).

Table 3 Number and type of complications after maxillotomy and endoscopic surgeries

Complication	Open-door maxillotomy (65)	Endoscopic transnasal (26)
Cerebrospinal fluid leak	3	2
Cardiovascular	2	0
Respiratory	18	0
Dysphagia	2	0
Hematoma	0	0
Pharyngeal wound infection	2	0
Sepsis	2	0
Meningitis	6	0
Velopharyngeal incompetence	13	0
Cranial nerve palsy	2	0
Cerebral infarction	0	1
Internal carotid artery injury	0	1
Death	6	0

Hemorrhage and CSF leakage are potential problems with the endoscopic approach.[21–25] In our series, there was one internal carotid artery injury and two CSF leaks. In comparison, there were a total of three CSF leaks in the open-door maxillotomy group, although these procedures were generally for more extensive tumor operations.

Discussion

Lesions in and around the clivus are traditionally approached through open anterior or lateral approaches.[1–6] Arguably the most direct of these approaches is through the midline by a maxillotomy, facial split technique, or extended transoral route.[7–10] However, these approaches are technically demanding and less acceptable to patients, and endoscopic transnasal surgery has recently become more popular, partly due to the trend and demand for minimally invasive surgery. Otolaryngologists initially performed endoscopic nasal surgery to treat sinus pathology[15,26,27] and later expanded the indications in collaboration with neurosurgeons, gaining a better understanding of the anatomy of the skull base and intracranial compartment. The endoscopic approach can also

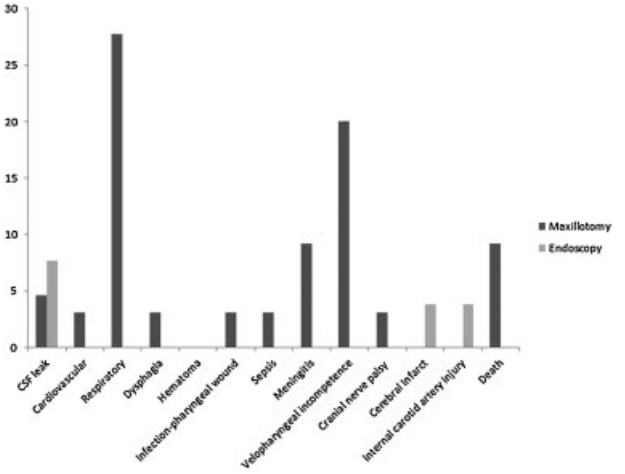

Fig. 3 Graph of percentage complications after maxillotomy and endoscopic surgeries. CSF, cerebrospinal fluid.

be used to treat lesions of the craniocervical junction.[20] We present our early results of patients treated by endoscopic surgery, compared with an earlier series of patients who underwent open maxillotomy at our hospital.

In our series, open maxillotomies were associated with a higher incidence of infection, meningitis, systemic sepsis, and respiratory complications, although this is an uncontrolled study, and the patients undergoing maxillotomy had greater comorbidity and worse grades of myelopathy before surgery, and different types and severity of pathology. A total of 28% of patients treated by the open approach experienced respiratory complication, 9% had meningitis, and 1.3% had systemic sepsis. In the endoscopic approach, these risks were far lower. In 20% of maxillotomy patients, velopharyngeal incompetence was noted with the open approach.

Endoscopic surgery has a steep learning curve. Snyderman et al analyzed their experience of endoscopic surgery for skull base pathology and proposed a training program for acquisition of these surgical skills.[28] In particular, CSF leakage can be a problem to repair with endoscopic surgery due to the limited view and space available. We demonstrate a 7.7% CSF leak rate in the endoscopic group as opposed to 4.6% in the open surgical group. A higher incidence of CSF leak rates after endoscopic surgery is well recognized, occurring in up to 31.6% of patients.[29–32] There was no vascular injury in the open group but one case of internal carotid artery injury in the endoscopic group.

Our results are comparable with other published reports. Neurologic morbidity rates for endoscopic skull base surgery ranges from 0 to 80%, vascular injuries are reported in 9 to 12%, and CSF leaks are reported in 8.3 to 30% of cases.[18,22,24,33]

Patients undergoing open maxillotomies have generally more advanced diseases than patients undergoing standard transoral surgery. The complication rate for standard transoral surgery is much lower, with a CSF leak rate of 1.3% and pharyngeal infection rate of 0.6% in our series.[34] Like Carrabba et al, we found that retrospectively comparing endoscopic and open surgeries was subject to selection bias, perhaps with more complex patients undergoing open surgeries.[29] However, preoperative tumor volumes were not significantly different between the two groups. The maxillotomy cohort generally underwent operations in the earlier years of this study, and obtaining routine postoperative MRI was not standard procedure at the time. Therefore, it was not possible to compare postoperative tumor volume and extent of resection between the maxillotomy and endoscopy groups. However, the philosophy of surgery in both groups was the same, namely to perform complete or near-complete excision wherever possible. Also, another potential bias is the heterogeneous types of pathologies presenting in the two groups. This being said, most other studies confirm a higher risk of complications in open surgery compared with endoscopic surgery. Casler et al found a greater risk of complications in the open group (53.3%) compared with the endoscopic group (26.7%).[30] Batra et al demonstrated a 22% major complication rate in endoscopic surgery, compared with 44% for open surgery.[35]

Open approaches theoretically may allow wider margins of tumor excision, and they may appear easier due to the wider approach, increased space for instruments and surgical maneuvers, and stereoscopic vision through an operating microscope. They also allow easier control of bleeding and CSF leakage. Endoscopic approaches are generally less destructive, avoiding osteotomies, and do not usually affect cosmesis. They allow enhanced visibility especially when using endoscopes with different angles of vision, and usually do not require tracheotomy or feeding tubes after surgery. However, endoscopy requires specialized and expensive equipment, and it lacks the depth of field perception of the operating microscope, although it is possible to appreciate depth of field by moving the endoscope toward and away from the region being observed in a dynamic fashion.

Conclusion

Open surgical approaches have long been considered the gold standard for treating lesions of the skull base, but recent advances in endoscopic techniques have increased the popularity of this method. Our series suggests that, in patients for whom open maxillotomy or endoscopic surgery are both feasible, the preference should be toward endoscopic surgery. In these patients, endoscopic surgery affords better visualization, potentially fewer complications, and is more acceptable to the patient. However, for midline pathology below the level of the hard palate, accessible via the oropharynx, we advocate that the standard transoral operation is a viable alternative to endoscopic surgery, with a lower infection and CSF leak rate than the endoscopic technique.

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