



Advantage of Extended Craniofacial Resection for Advanced Malignant Tumors of the Nasal Cavity and Paranasal Sinuses: Long-Term Outcome and Surgical Management

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■ **OBJECTIVE:** Craniofacial resection (CFR) for advanced sinonasal malignant tumors (SNMTs) is mandatory for radical resection. Surgeons must be aware of perioperative complications and long-term outcome because this procedure is extremely invasive, especially when the tumor involves the anterior skull base.

■ **METHODS:** Thirty-eight consecutive surgical patients with advanced SNMT of T4 stage or Kadish stage C (31 men and 7 women; mean age, 55 years; range: 19–76 years) treated with CFR in the past 28 years were followed up for 59.4 months. In cases of unilateral orbital extension, en-bloc resection was achieved using several neurosurgical techniques (extended CFR) from 2005 onwards. Herein, we evaluated the safety and effectiveness of surgery by comparing survival data between 2 time periods (first stage: 1984–2004, second stage: 2005–2012).

■ **RESULTS:** Squamous cell carcinoma was the most common histological type observed (65.8%), followed by esthesioneuroblastoma (15.8%). Using a combination of adjuvant radiation therapy, the 5-year overall survival and the 5-year disease-specific survival rates were 55.5% and 59.4%, respectively. Sarcomatous histology was a poor prognostic factor. The 5-year disease-specific survival rate was 48.9% in the first stage and improved to 82.1% in the

second stage ($P = 0.057$); this was related to improvements in local control rate.

■ **CONCLUSIONS:** CFR and postoperative radiotherapy are safe and effective for treating advanced SNMTs. Extended CFR, including radical orbital exenteration, may contribute to good long-term outcomes. A diverse surgical team may help perform radical resection and reconstruction in patients with advanced tumors.

INTRODUCTION

Cancers of the nasal cavity and paranasal sinuses (sinonasal malignant tumors [SNMTs]) are rare, only accounting for 3%–5% of all head-and-neck cancers and 0.5%–1% of all newly diagnosed cancers. The annual incidence of SNMT is 0.5–1.0 per 100,000 people,^{1,3} and it is high in Asia, particularly in Japan.^{4,5} These tumors often grow silently and are therefore usually already in the advanced stage at the time of diagnosis.⁶ Particularly, in cases of advanced-stage SNMT involving the anterior skull base, a combination of complete surgical resection and postoperative radiotherapy is recommended as the only possible treatment to ensure patient survival. However, as this cancer is rare and involves several pathologic entities, until now,

Key words

- Anterior skull base
- Craniofacial resection
- En-bloc resection
- Long-term outcome
- Orbital exenteration
- Paranasal sinus
- Sinonasal malignant tumors

Abbreviations and Acronyms

- CFR:** Craniofacial resection
- CSF:** Cerebrospinal fluid
- CT:** Computed tomography
- DFS:** Disease-free survival
- DMFR:** Distant metastasis-free rate
- DSS:** Disease-specific survival
- Gy:** Gray

ICA: Internal carotid artery

LCS: Local control rate

OS: Overall survival

SNMT: Sinonasal malignant tumor

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Citation: *World Neurosurg.* (2016) 89:240–254.
<http://dx.doi.org/10.1016/j.wneu.2016.02.019>

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

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there have been no clear or detailed treatment guidelines available for advanced SNMT.

Ketcham et al. established the anterior craniofacial resection (CFR) in 1963; this is now widely recognized as the gold standard surgical approach for SNMT involving the cribriform plate.⁷⁻⁹ Since then, several modifications and some skull base reconstruction techniques have been reported.^{10,11} Ten years ago, an international collaborative study on CFR for SNMT was performed¹²; CFR was reported to be a safe and effective treatment option for patients with SNMT. However, CFR is considered a highly invasive treatment compared with other surgeries for different cancers. In contrast to radical surgical resection, other treatment modalities such as endoscopic transnasal resection, intra-arterial chemoradiotherapy, and particle beam therapy have recently emerged as less invasive and organ-preserving treatments for sinonasal malignancies.¹³⁻²⁰

Generally, it has been considered a dogma that piecemeal resection should be avoided as far as possible whereby efficient surgical resection with clear margins must be achieved due to the anatomic complexity and spread of disease, especially in patients with head and neck cancers.²¹ However, while performing radical en-bloc resection, maximum effort needs to be directed towards preventing perioperative life-threatening complications.

Since 1984, we have performed CFR for 38 patients with advanced SNMT and introduced extended CFR after 2005. Extended CFR is a modification of classic CFR and enables en-bloc resection in patients requiring orbital exenteration. The present study aimed to investigate the long-term outcome of CFR and determine whether it is safe and effective for patients with advanced SNMT. Furthermore, we demonstrate that “en-bloc” tumor resection using several neurosurgical techniques has several advantages compared with “classic component-oriented” tumor resection.

MATERIAL AND METHODS

Patient Characteristics

Between May 1984 and May 2012, 38 CFRs were performed at Kurume University Hospital. The operations were performed in collaboration with surgeons from the departments of otolaryngology, head and neck surgery, neurosurgery, and plastic and reconstructive surgery/maxillofacial surgery. All patients had stage T4 tumors, as per the TNM classification of malignant tumors developed by the seventh edition of the Union for International Cancer Control, or Kadish stage C in cases of esthesioneuroblastoma.

The included patients comprised 31 men and 7 women, with a median age of 55.5 years (range, 19–76 years). The primary tumor site was the ethmoid sinus in 16 cases, maxillary sinus in 9 cases, frontal sinus in 3 cases, and olfactory cleavage/nasal cavity in 10 cases. Twenty-eight patients were newly diagnosed with nasal/paranasal sinus tumor, generally confirmed by transnasal biopsy. The remaining 10 patients, who had undergone surgery and radiotherapy previously for early stage tumors, required a salvage operation due to advanced recurrent tumors, mainly malignant tumors of the maxillary sinus. Following the exclusion of 6 patients with Kadish stage C esthesioneuroblastomas, we treated 32 patients comprising 16 (50%) with stage T4a and 16 (50%) with stage T4b tumors.

We performed classic CFR between 1984 and 2004 (first stage) and introduced the extended modified approach of classic CFR, “Extended CFR,” in surgical procedures from 2005 to present (second stage), although we did not change the principal surgical concepts except for additional prophylactic tracheostomy. There was no statistical difference in patient clinical characteristics between the 2 stages (Table 1).

Eligibility Criteria for CFR

All referral patients with advanced SNMT were initially evaluated by an otolaryngologist through whole-body, contrast-enhanced computed tomography (CT) or positron emission tomography. At this point, approximately half of the cases were excluded for reasons such as distant metastasis and elderly age with poor general condition. After histologic confirmation through endoscopic transnasal biopsy, we routinely held team conferences involving head-and-neck surgeons and radiation oncologists. We carefully assessed tumor resectability and the optimal resection line of each patient according to the following 7 radiographical points: 1) cavernous sinus extension, 2) unresectable deep brain invasion, 3) bilateral orbital extension, 4) orbital apex invasion, 5) petrous internal carotid artery (ICA) involvement, 6) sellar or clival involvement, and 7) distant metastasis. Advanced SNMTs with regional small neck lymph node metastasis were included for surgical indication and were treated by additional radical neck dissection during the planned CFR. Patients with a more advanced tumor or those who refused surgical resection were usually treated by intra-arterial chemoradiotherapy.

Management of the Orbit During CFR

In the cases where advanced SNMT had invaded the intraorbital contents beyond the lamina papyracea, we resected the intra-orbital contents of the affected side along with the tumor. As esthesioneuroblastomas differ from other SNMTs regarding their malignancy and radiosensitivity, we attempted to preserve the orbital content in these cases, if the tumor had invaded to the depth of the periorbita. A total of 24 out of the 38 patients required the extraction of orbital contents (see Table 1).

Surgical Techniques

A spinal drain was inserted after anesthesia induction to facilitate cerebrospinal fluid (CSF) decompression in all cases. Standard (classic CFR) and extended surgical procedures (extended CFR) are described as follows.

Standard Surgical Procedures (Classic CFR). The standard techniques for classic CFR have been extensively described previously.^{8,9,22-24} We present a brief outline of the surgical steps in an exemplary case in Figure 1. Preparation and reconstruction techniques using bilateral temporal musculopericranial flap for anterior skull base defects have also been described in detail previously.²⁵

In cases where the tumor had invaded into the subdural space, the surrounding frontal lobe was also resected to prevent exposing the tumor. If the intracranial tumor was large and unfeasible for en-bloc resection, this component was resected by intratumoral debulking with standard microsurgical techniques. However, these situations were usually restricted to Kadish C esthesioneuroblastoma cases.

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