oropharynx for the presence or absence of pathological metastasis were assessed using the chi-squared test, and P values <0.05 were considered statistically significant.

Results

Patient characteristics

In this study, 61 patients with oropharyngeal carcinoma and 41 patients with hypopharyngeal carcinoma with nodal stage N2–3 in whom a CR was achieved at the primary tumor received ICT followed by CRT/RT (Table 1). Fifty-six patients showed a CR in the neck on imaging examinations. Non-CR in the neck was observed in 46 cases. Ten patients who showed a CR in the neck after receiving CRT underwent ND followed by planned ND. We followed the remaining 46 cases of CR in the neck without ND, while 32 patients with non-CR in the neck underwent ND as an early salvage intervention. We followed the 14 other patients with non-CR in the neck who did not want ND, and we performed salvage surgery, if possible, when recurrence was noted. The follow-up period ranged from 6.9 to 89.6 months. The mean age of the patients was 62.3 years (range 36–78 years).

Table 1 Patient characteristics

	OPC (n = 61)	HPC (n = 41)
Age (years)		
Range	30–78	42–74
Median	60	62
Sex		
Male	55 (90 %)	39 (95 %)
Female	6 (10 %)	2 (5 %)
Primary tumor stage		
T1	4 (7 %)	6 (15 %)
T2	28 (46 %)	17 (41 %)
T3	17 (28 %)	12 (29 %)
T4	12 (20 %)	6 (15 %)
Clinical nodal stage		
cN2a	12 (20 %)	6 (15 %)
cN2b	22 (36 %)	20 (49 %)
cN2c	18 (30 %)	13 (32 %)
cN3	9 (15 %)	2 (5 %)
Nodal response		
CR	34 (56 %)	22 (54 %)
Observe	30	16
Neck dissection (planned ND)	4	6
PR	27 (44 %)	19 (46 %)
Neck dissection (early salvage ND)	20	12
Observe (reject)	7	7

ND neck dissection, *OPC* oropharyngeal carcinoma, *HPC* hypopharyngeal carcinoma, *CR* complete response, *PR* partial response

Prognostic impact of neck dissection after chemoradiotherapy

Figure 1 shows the regional control rate and Fig. 2 shows the overall survival rate. Even CR cases included regional recurrence, and all CR cases in the neck were salvaged successfully and the 5-year overall survival rate was 92.8 %. In cases of non-CR in the neck, the regional control rate was significantly better in the group that underwent ND ($P = 0.0358$).

During follow-up, 14 of 42 patients who underwent ND suffered a relapse: five involved locoregional recurrence (four of five cases were successfully salvaged) and nine involved recurrence with distant metastasis. The primary cause of a recurrence following post-CRT ND was distant metastasis.

Neck dissection and pathological results

A summary of cases in which ND was performed is shown in Table 2 according to the type of ND. We examined the

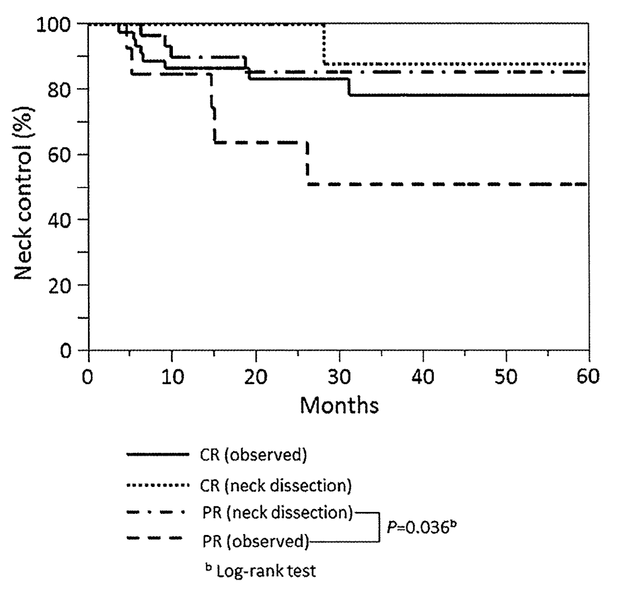

Fig. 1 Regional control rate. Kaplan–Meier survival curves for the associations between neck response (with or without ND) and regional control. In cases of CR of the neck, the 5-year regional control rate was 87.5 % for the ND group, and 78.2 % for the observed group, respectively. In cases of non-CR of the neck, the 5-year regional control rate was 85.8 % for the ND group, and 51.1 % for the observed group, respectively ($P = 0.036$)

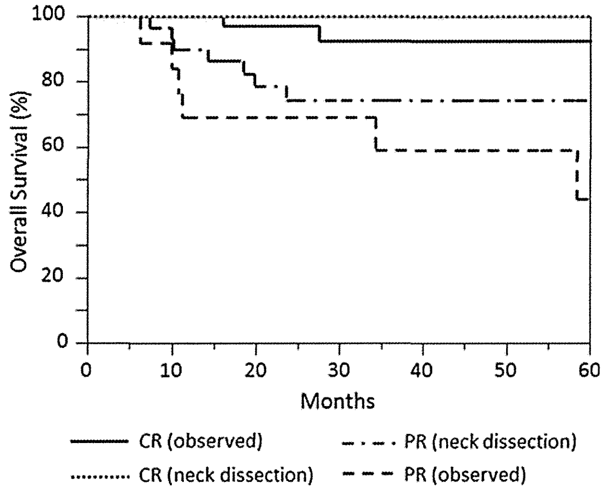

Fig. 2 Overall survival. Kaplan–Meier survival curves for the associations between neck response (with or without ND) and overall survival. In cases of CR of the neck, the 5-year overall survival was 100 % for the ND group, and 92.8 % for the observed group, respectively. In cases of non-CR of the neck, the 5-year overall survival was 74.6 % for the ND group, and 44.5 % for the observed group, respectively

Table 2 Type of neck dissection

	Total	OPC	HPC
Neck dissections: cases	42	24	18
Hemi neck dissection: sides	48	29	19
Comprehensive ND	25	21	4
Selective ND	23	8	15
II, III, IV	10	6	4
II, III, IV, V	11	–	11
I, II, III	1	1	–
I, II, III, IV	1	1	–

ND neck dissection, *OPC* oropharyngeal carcinoma, *HPC* hypopharyngeal carcinoma

results of pathological metastasis in ND cases. The presence or absence of pathological metastases as a result of ND is shown in Table 3. We also compared the hypopharynx and oropharynx for the presence or absence of pathological metastasis. There were no significant differences in the ratios of pathological metastasis depending on the primary site.

We analyzed the impact of the presence or absence of pathological metastasis on prognosis in cases of ND (Fig. 3). Patients without pathological CLN metastases had a significantly better recurrence-free survival than those with pathological CLN metastasis.

Table 3 Pathological findings after neck dissection

	pN(+)	pN(−)	*P* value
Neck response			0.28[a]
CR	3 (30.0 %)	7 (70.0 %)	
PR	18 (56.3 %)	14 (43.8 %)	
Primary site			0.76[a]
Oropharynx	11 (45.8 %)	13 (54.2 %)	
Hypopharynx	10 (55.6 %)	8 (44.4 %)	

CR complete response, *PR* partial response

[a] Chi square test

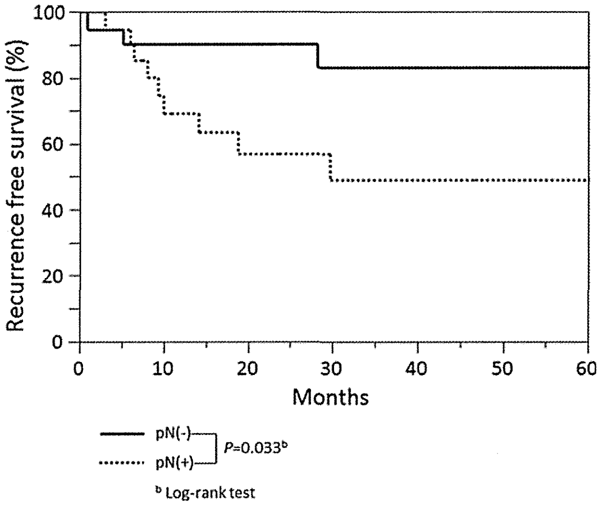

Fig. 3 Recurrence-free survival. Recurrence-free survival for patients who underwent ND depends on the pathological cervical lymph node (CLN) metastasis. The 5-year recurrence-free survival was 83.5 % for patients without pathological CLN metastases, and 49.3 % for patients with pathological CLN metastases, respectively ($P = 0.033$)

Distribution of cervical lymph node metastasis

The distribution of CLN metastasis in the oropharyngeal and hypopharyngeal cases is shown in Figs. 4 and 5, respectively. The percentage indicates the positive rate of pathological CLN metastasis in the dissection area (level or sublevel). The denominator indicates the number of the (sub)level at which the dissection was performed, and the numerator indicates the present (sub)level number of pathological metastases. No recurrence of ipsilateral CLN was found in these cases. Even when ND was selective, no cases of recurrence at the preserved ipsilateral neck level were observed in this study. CLN recurrence occurred in four cases: three cases involved CLN metastasis on the contralateral side, and the other case involved metastasis to the ipsilateral retropharyngeal node.

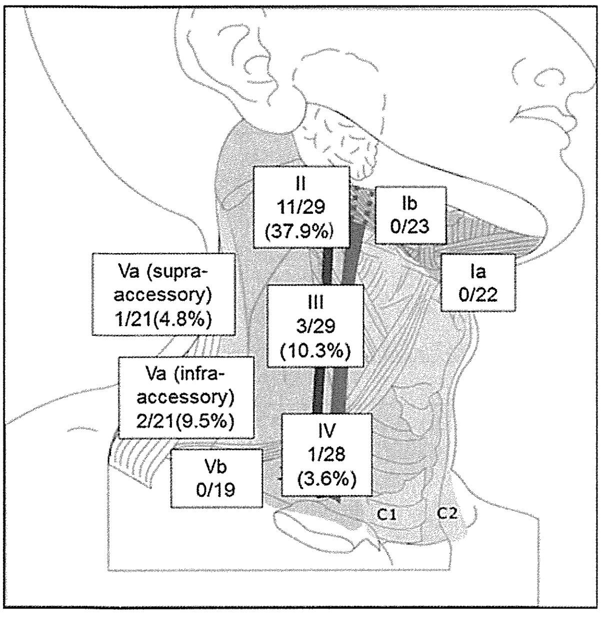

Fig. 4 Distribution of lymph node metastasis: oropharynx

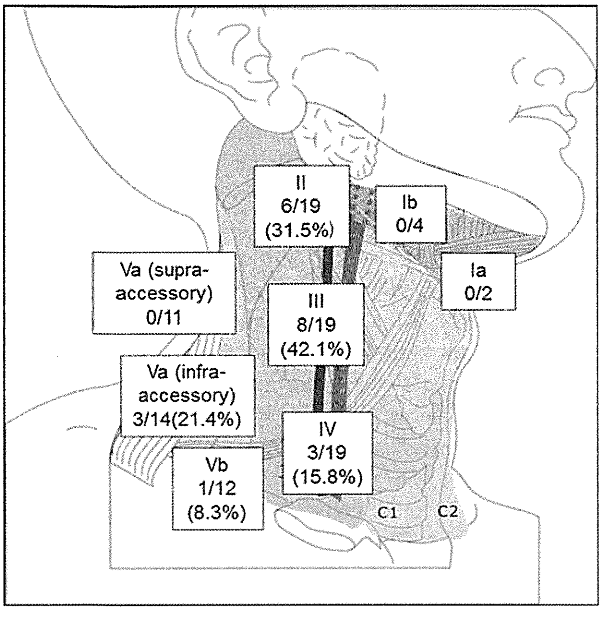

Fig. 5 Distribution of lymph node metastasis: hypopharynx

The location of CLN metastasis-positive levels is shown in Table 4. Histologically proven distribution to level V metastasis was detected in 12 % of oropharyngeal cases and 15 % of hypopharyngeal cases. Hence, performing selective ND at levels II–IV can contain 88 % of CLN metastases in oropharyngeal cases and 85 % of CLN metastases in hypopharyngeal cases.

Table 4 Location of positive levels

	Oropharynx	Hypopharynx
Level I	0	0
Level II	11 (65 %)	6 (30 %)
Level III	3 (18 %)	8 (40 %)
Level IV	1 (6 %)	3 (15 %)
Level V	2 (12 %)	3 (15 %)
SND (level II–IV)	15/17 (88 %)	17/20 (85 %)

SND selective neck dissection

Table 5 shows a list of cases with histologically proven CLN metastasis at level V. Although few in number, all of these cases involved distant metastasis.

Complications

Eight patients (19.0 %) experienced postoperative complications from ND: four cases of laryngeal edema, two cases of lymph fluid leakage, one case of lingual nerve paralysis and dysphagia and one case of wound infection. Three of the four patients with laryngeal edema underwent tracheostomy. Six of the eight complications were caused by comprehensive ND (24.0 %). Among patients who underwent selective neck dissection, two complications (laryngeal edema and wound infection) were seen (8.6 %).

Discussion

In the treatment of OHSCC, the use of CRT for the purpose of organ preservation has been increasing, especially in recent years. Therefore, ND may not be performed as first-line therapy, but rather as second-line therapy for CRT as part of combined modality therapy. The current way of thinking is to determine the need for ND after CRT based on imaging examinations [16, 17]. In this study, there were no significant differences in the regional control rates in cases judged to show a CR on imaging examinations. However, even when judged to show a CR on imaging examinations, CLN recurrence was found in a few cases, and performing salvage was possible in each case. In other words, even if planned ND was not performed in CR cases, the same treatment outcomes were obtained by performing salvage when recurrence or progression was noted. There is the problem, however, of difficulty in performing late salvage. In cases without a CR in the neck, performing early salvage intervention should be considered necessary.

It was also shown in this study that prognoses were poor in cases of pathological CLN metastasis. Earlier studies [18, 19] have previously shown similar results. We retrospectively examined the distribution of CLN metastasis in

Table 5 Summary of the cases with level V metastasis

Primary site	Clinical stage	Pre-operative findings	Modality	Type of ND	Pathology	Recurrence site	Disease-free interval (months)	Prognosis
Oropharynx	T2N3 (bilateral)	lt III(+)	PET-CT	bl CND (I–V)	rt V:1; lt II:1, V:2	Lung	14	NED (surgery)
Hypopharynx	T1N2b	lt III(+)	PET–CT	SND (II–V)	II:5, III:4, IV:1, V:1	Local, RPN, contra-neck, mediastinal LN, lung	10	DOD
Hypopharynx	T2N2b	CR	CT	SND (II–V)	III:1, V:1	Axillary LN	6	NED (CTx, RTx)
Hypopharynx	T4aN2b	PR	CT	SND (II–V)	II:3, III:3, IV:3, V:6	Trachea, mediastinal LN	11	AWD

lt left, *bl* bilateral, *rt* right, *CR* complete response, *PR* partial response, *CND* comprehensive neck dissection, *SND* selective neck dissection, *RPN* retropharyngeal node, *LN* lymph node, *AWD* alive with disease, *NED* no evidence of disease, *DOD* died of disease

dissected cases to clarify the appropriate surgical extent of ND. We found that the majority of CLNs can be contained by performing selective ND assuming levels II–IV as a basis [20, 21] after CRT. However, even though recommendations regarding the surgical extent of ND are the same for oropharyngeal and hypopharyngeal cancer, differences were found in the distribution and extent of metastasis between the oropharynx and hypopharynx; therefore, they cannot be discussed equally. Hypopharyngeal cancer often shows more extensive metastasis than oropharyngeal cancer. Careful examination is needed; however, performing super-selective ND [22, 23] might be possible in cases of oropharyngeal cancer. Super-selective ND is a new concept, not yet generally accepted, and is a more targeted neck dissection that involves removing the single neck level and its adjacent level in cases with clinical evidence of persistent nodal disease confined to a single neck level [24]. In this study, the distribution of persistent nodal disease of oropharyngeal cases was relatively confined, with almost all of the CLN metastases located in levels II and III. Therefore, super-selective ND removing level II and III for oropharyngeal cases might be effective.

We also found it necessary to take into account not only the CLN metastasis situation, but also the prognosis, in determining the indications for post-CRT ND and the appropriate surgical extent of ND.

When recurrence appears as a distant metastasis over a short period, the ND procedure itself is often considered to be ineffective for survival prognosis. Although we were able to contain the majority of CLN metastases by performing level II–IV selective ND in this study, metastasis to level V is not insignificant enough to be considered negligible. However, distant metastases occurred in all cases with pathological CLN metastasis at level V found during ND following CRT. This shows that, in disseminated lesions with metastatic persistence to level V, the likelihood that distant metastasis has already occurred is very high. In other words, the presence of CLN metastasis at level V after CRT appears to be an indicator of distant metastasis.

In this study, metastases to level V were found pathologically during and/or after post-CRT ND. Residual CLNs were not actually suspected at level V on imaging examinations performed just before ND. Prior to administering treatment in these cases, multiple CLN metastases were detected along the jugular chain: metastasis to the posterior neck developed in two cases; however, only equivocally sized LNs were detected at level V on imaging examinations in the other two cases. In one case, comprehensive ND had been planned beforehand and the presence of metastasis was proven after performing a histopathological examination; however, this was at a time when we had not yet performed selective ND. In the other cases, we extended the range of ND to level V based on intraoperative clinical findings. We should assume the existence of concomitant distant metastasis and consider subsequent treatment when metastasis is found in level V. In addition, if metastasis is detected in level V before performing ND, one must reconsider whether ND is indicated.

Additionally, the postoperative complication rate is obviously lower in selective ND cases than in comprehensive ND cases. Therefore, in this study, we consider the proper extent of post-CRT ND of OHSCC to include selective ND of levels II–IV.

This study had limitations, including its retrospective design and the conditions of CLN metastasis. Since ND is performed at a relatively early stage after the administration of CRT, there is a question as to the viability of persistent CLN metastasis on specimens [25]. It is unknown whether these cancers remain merely on the basis of observation. If the timing of ND is delayed a little, the proportion of metastases present may change. Imaging examinations were also performed in this study at earlier times than the current consensus [26, 27]. The diagnostic accuracy rate of PET–CT improves 10 or 12 weeks after the completion of CRT [28, 29]. The usefulness of PET–CT will be improved by appropriately adjusting its timing. In this study, PET–CT was performed approximately 6–8 weeks after the completion of CRT. The rationale for early PET was based on the former policy of planned ND. Due the retrospective nature of the present study, we used to determine that the optimal timing for operative intervention before the occurrence of extensive fibrosis and scarring was approximately 6–8 weeks after the completion of CRT. This is one of the methodological limitations of this study. However, PET–CT has a high negative predictive value even if it is employed earlier [30]. Therefore, we did not perform ND in the cases that we could judge to be a CR by PET–CT, but did perform ND when the results were inconclusive. In cases judged to show a CR on imaging examinations, pathological CLN metastasis was found in 30 % of cases (false negative). When we performed ND in CR cases that conformed to planned ND, the residual rate of CLN metastasis was similar to the results of earlier studies of planned ND [31]. With regard to the pathologically negative CLN in the nodal PR cases (false positive), the early timing of imaging examinations influenced the results. In this study, the viable tumor rate in the nodal PR cases was 56.3 %. Similarly, the published literature suggests that the viable tumor rate is about 50 % in residual nodes [32].

It should also be noted that this study did not investigate the status of human papilloma virus (HPV). Because responses to CRT are different in HPV-positive cases, it is necessary to take this issue into account in the future. In recent cases, we assessed HPV status in oropharyngeal cases using multiplex PCR with sets of HPV genotype-specific primers. We also confirmed that HPV-positive oropharyngeal cancer patients showed good responses to CRT and that their clinical courses were superior to those of HPV-negative oropharyngeal patients.

In conclusion, this investigation of ND performed after CRT revealed not only that the presence of pathological CLN metastasis affects prognosis, but also that a diffuse distribution of CLN metastasis including level V after CRT worsens prognosis. Based on the results of this study, we showed that the proper extent of post-CRT ND of OHSCC is selective ND including levels II–IV. Because the presence of CLN metastasis at level V after CRT appears to be an indicator of distant metastasis, ND is not a realistic salvage treatment in such situations. New treatment strategies are needed in cases of precursors of distant metastasis.

Acknowledgments This work was supported by a Health and Labour Sciences Research Grant for Clinical Cancer Research (H20-Gannrinshou-Ippan-014) from the Ministry of Health, Labour and Welfare, Japan.

Conflict of interest No author has any conflict of interest.

References

1. Vokes EE, Kies MS, Haraf DJ et al (2000) Concomitant chemoradiotherapy as primary therapy for locoregionally advanced head and neck cancer. J Clin Oncol 18:1652–1661
2. Kutler DI, Patel SG, Shah JP (2004) The role of neck dissection following definitive chemoradiation. Oncology (Williston Park) 18:993–998
3. Maran AG, Amin M, Wilson JA (1989) Radical neck dissection: a 19-year experience. J Laryngol Otol 103:760–764
4. Machtay M, Moughan J, Trotti A et al (2008) Factors associated with severe late toxicity after concurrent chemoradiation for locally advanced head and neck cancer: an RTOG analysis. J Clin Oncol 26:3582–3589
5. Mendenhall WM, Million RR, Cassisi NJ (1986) Squamous cell carcinoma of the head and neck treated with radiation therapy: the role of neck dissection for clinically positive neck nodes. Int J Radiat Oncol Biol Phys 12:733–740
6. Mendenhall WM, Parsons JT, Amdur RJ et al (1988) Squamous cell carcinoma of the head and neck treated with radiotherapy: does planned neck dissection reduce the change for successful surgical management of subsequent local recurrence? Head Neck Surg 10:302–304
7. Ferlito A, Corry J, Silver CE et al (2010) Planned neck dissection for patients with complete response to chemoradiotherapy: a concept approaching obsolescence. Head Neck 32:253–261
8. Corry J, Peters L, Fisher R et al (2008) N2–N3 neck nodal control without planned neck dissection for clinical/radiologic complete responders—results of Trans Tasman Radiation Oncology Group Study 98.02. Head Neck 30:737–742
9. Nouraei SA, Upile T, Al-Yaghchi C et al (2008) Role of planned postchemoradiotherapy selective neck dissection in the multimodality management of head and neck cancer. Laryngoscope 118:797–803
10. Stenson KM, Huo D, Blair E et al (2006) Planned post chemoradiation neck dissection: significance of radiation dose. Laryngoscope 116:33–36
11. The Department of Veterans Affairs Laryngeal Cancer Study Group (1991) Induction chemotherapy plus radiation compared with surgery plus radiation in patients with advanced laryngeal cancer: the Department of Veterans Affairs Laryngeal Cancer Study Group. N Engl J Med 324:1685–1690
12. Urba S, Wolf G, Eisbruch A et al (2006) Single-cycle induction chemotherapy selects patients with advanced laryngeal cancer for combined chemoradiation: a new treatment paradigm. J Clin Oncol 24:593–598
13. Worden FP, Wolf GT, Eisbruch A et al (2006) Chemo-selection of patients for organ preservation in advanced laryngeal cancer: failure of chemotherapy as the sole treatment for complete histologic responders to neoadjuvant chemotherapy. J Clin Oncol 24(suppl):18S (abstract 5560)
14. Worden FP, Moyer J, Lee JS et al (2009) Chemoselection as a strategy for organ preservation in patients with T4 laryngeal squamous cell carcinoma with cartilage invasion. Laryngoscope 119:1510–1517
15. Som PM (1992) Detection of metastasis in cervical lymph nodes: CT and MR criteria and differential diagnosis. Am J Roentgenol 158:961–969
16. Corry J, Peters L, Fisher R et al (2008) N2–N3 neck nodal control without planned neck dissection for clinical/radiologic complete responders—results of Trans Tasman Radiation Oncology Group Study 98.02. Head Neck 30:737–742

17. Lavertu P, Adelstein DJ, Saxton JP et al (1997) Management of the neck in a randomized trial comparing concurrent chemotherapy and radiotherapy with radiotherapy alone in resectable stage III and IV squamous cell head and neck cancer. Head Neck 19:559–566
18. Ahlberg A, Lagerlund M, Lewin F et al (2008) Clinical outcome following radiotherapy and planned neck dissection in N+ head and neck cancer patients. Acta Otolaryngol 128:1354–1360
19. Ganly I, Bocker J, Carlson DL et al (2011) Viable tumor in postchemoradiation neck dissection specimens as an indicator of poor outcome. Head Neck 33:1387–1393
20. Boyd TS, Harari PM, Tannehill SP et al (1998) Planned postradiotherapy neck dissection in patients with advanced head and neck cancer. Head Neck 20:132–137
21. Doweck I, Robbins KT, Mendenhall WM et al (2003) Neck level-specific nodal metastases in oropharyngeal cancer: is there a role for selective neck dissection after definitive radiation therapy? Head Neck 25:960–967
22. Robbins KT, Shannon K, Vieira F et al (2007) Superselective neck dissection after chemoradiation: feasibility based on clinical and pathologic comparisons. Arch Otolaryngol Head Neck Surg 133:486–489
23. Sandau A, Rao N, Giri S et al (2009) Role and extent of neck dissection for persistent nodal disease following chemo-radiotherapy for locally advanced head and neck cancer: how much is enough? Acta Oncol 47:948–953
24. Robbins KT, Dhiwakar M, Vieira F et al (2012) Efficacy of super-selective neck dissection following chemoradiation for advanced head and neck cancer. Oral Oncol 48:1185–1189
25. Strasser MD, Gleich LL, Miller MA et al (1999) Management implications of evaluating the N2 and N3 neck after organ preservation therapy. Laryngoscope 109:1776–1780
26. NCCN® Practice guidelines in oncology, v.2.2010: head and neck cancers. Principles of surgery (post chemoradiation or RT neck evaluation). http://www.nccn.org/professionals/physician_gls/f_guidelines.asp
27. Wee JT, Anderson BO, Corry J et al (2009) Management of the neck after chemoradiotherapy for head and neck cancers in Asia: consensus statement from the Asian Oncology Summit 2009. Lancet Oncol 10:1086–1092
28. Isles MG, McConkey C, Mehanna HM (2008) A systematic review and meta-analysis of the role of positron emission tomography in the follow up of head and neck squamous cell carcinoma following radiotherapy or chemoradiotherapy. Clin Otolaryngol 33:210–222
29. Ong SC, Schöder H, Lee NY et al (2008) Clinical utility of 18F-FDG PET/CT in assessing the neck after concurrent chemoradiotherapy for locoregional advanced head and neck cancer. J Nucl Med 49:532–540
30. Malone JP, Gerberi MA, Vasireddy S et al (2009) Early prediction of response to chemoradiotherapy for head and neck cancer: reliability of restaging with combined positron emission tomography and computed tomography. Arch Otolaryngol Head Neck Surg 135:1119–1125
31. Ganly I, Bocker J, Carlson DL et al (2011) Viable tumor in postchemoradiation neck dissection specimens as an indicator of poor outcome. Head Neck 33:1387–1393
32. Clayman GL, Johnson CJ 2nd, Morrison W et al (2001) The role of neck dissection after chemoradiotherapy for oropharyngeal cancer with advanced nodal disease. Arch Otolaryngol Head Neck Surg 127:135–139

Eur Arch Otorhinolaryngol (2014) 271:589–597
DOI 10.1007/s00405-013-2575-0

HEAD AND NECK

Transoral videolaryngoscopic surgery for oropharyngeal, hypopharyngeal, and supraglottic cancer

Masayuki Tomifuji · Koji Araki · Taku Yamashita · Akihiro Shiotani

Received: 27 February 2013 / Accepted: 22 May 2013 / Published online: 1 June 2013

Abstract In this retrospective cohort study, we evaluated the oncological and functional outcomes of transoral videolaryngoscopic surgery (TOVS). Using distending laryngoscope and videolaryngoscope, wide operative field and working space could be obtained and tumor could be resected in en bloc. Sixty patients with T1, T2, and selected T3 laryngeal or pharyngeal squamous cell carcinomas (Stage I: $n = 17$, Stage II: $n = 16$, Stage III: $n = 7$, Stage IV: $n = 20$ cases) were enrolled and followed up for at least 24 months or until the patient's death. Fifty-three patients underwent initial treatment, and seven patients had recurrent cancer after chemoradiation. In principle, node-positive patients underwent a simultaneous neck dissection. Patients with multiple nodal metastases or a positive surgical margin received postoperative radiotherapy. For initial treatment, the 5-year overall survival and disease-specific survival rates were 77 and 95 %, respectively. For supraglottic and hypopharyngeal cancers, the 5-year laryngeal preservation rates were 89 and 96 %, respectively. For salvage surgery, the overall survival, disease-specific survival, and laryngeal preservation rates were 75, 75, and 80 %, respectively. The median times before patients could resume eating and swallowing a soft diet were 6 and 9 days, respectively. The patients' Functional Outcome Swallowing Scale stages were 0–2 in 93.3 % of the cases and 3 or 4 in 6.7 % of the cases. A percutaneous endoscopic gastrostomy was indicated for 1 (1.7 %) patient. Four (6.7 %) patients received transient tracheostomy. TOVS is a satisfactory and minimally invasive treatment option for laryngeal and pharyngeal cancers.

Keywords Hypopharyngeal cancer · Oropharyngeal cancer · Supraglottic cancer · Transoral surgery · Videolaryngoscope

M. Tomifuji · K. Araki · T. Yamashita · A. Shiotani (✉)
Department of Otolaryngology-Head and Neck Surgery, National Defense Medical College, 3-2 Namiki, Tokorozawa, Saitama 359-8513, Japan
e-mail: ashiotan@ndmc.ac.jp

Introduction

Most head and neck cancer patients prefer to undergo organ preservation treatment if it is indicated. Three organ preservation strategies are used in the laryngeal and pharyngeal regions: (1) radiation or chemoradiation, (2) open partial laryngopharyngectomy, and (3) transoral surgery. Chemoradiation is the most common organ preservation strategy, but many patients subsequently suffer from swallowing dysfunction. In a review article by Hutcheson and Lewin [1], the feeding tube dependency rate after chemoradiation was reportedly 3–41 % at 1 year and 3–22 % at 2 years after treatment. Open partial laryngopharyngectomy remains the treatment of choice in selected patients. However, it is becoming less common because it is surgically invasive, requires reconstructive surgery with tracheostomy, and results in postoperative functional problems.

Since the 1990s, transoral laser microsurgery (TLM) has been recognized as an organ preservation strategy that reportedly has good oncological control and good functional results [2–6]. TLM is performed using a microscope; the tumor is usually bisected or resected in multiple blocks [7]. Experience in TLM is important to demonstrate that transoral surgery can show a good oncological outcome and less morbidity in selected patients with upper aerodigestive tract cancer. However, the disadvantage of TLM is that the surgical view under the microscope is narrow, necessitating frequent repositioning of the laryngoscope. Moreover, a precise pathological evaluation is difficult if a tumor is resected in multiple blocks.

Primarily in the USA, transoral robotic surgery (TORS) is gaining popularity as a new treatment modality for oropharyngeal, supraglottic, and hypopharyngeal cancer [8–12]. Surgical robots are widely used in the USA; however, they are expensive and unavailable in many hospitals in many countries.

Since 2004, we have been developing a new transoral surgery system for laryngopharyngeal lesions to address these problems [13–15]. In this system, a laryngeal or pharyngeal lesion is exposed using a Weerda distending laryngoscope or an FK retractor. A surgical assistant manages a rigid videolaryngoscope to obtain the appropriate view. While watching the endoscopic view on a monitor, the operator manipulates laparoscopic surgical instruments such as forceps, scissors, and electrocautery needles. This system allows the surgeon to obtain a wide surgical field and view. We have named this procedure transoral videolaryngoscopic surgery (TOVS). The purpose of this study was to assess survival outcome, organ preservation rate, postoperative swallowing function, and surgical complications in patients undergoing TOVS.

Methods

Surgical indication

T1, T2, and selected T3 cancers of the supraglottis, oropharynx, or hypopharynx were indications for TOVS. In salvage surgery after chemoradiotherapy, the indication for TOVS was restricted to patients with rT1 or rT2 cancer. Node-positive patients were also included if the tumor was resectable.

The exclusion criteria were (1) a tumor that invaded the thyroid cartilage, hyoid bone, or cricoid cartilage or (2) a tumor that extended to more than one-half of the esophageal inlet. These were included as exclusion criteria because an en bloc resection with the thyroid cartilage, hyoid bone, or cricoid cartilage is technically difficult and resection of more than one-half of the esophageal inlet may cause severe pharyngeal stenosis. These patients were offered other treatments such as chemoradiation, open partial laryngopharyngectomy, total laryngectomy, or total laryngopharyngectomy.

Surgical procedures

Under general anesthesia with oral endotracheal intubation, the most appropriate surgical view was obtained using a Weerda distending laryngoscope (Karl Storz, Tuttlingen, Germany), an FK retractor (Gyrus ACMI, Southborough, Massachusetts), or a Crowe Davis retractor (Nagashima Medical Instruments, Tokyo, Japan). For oropharyngeal lesions, a Crowe Davis retractor or an FK retractor with a tongue blade was used. For laryngeal and hypopharyngeal lesions, an FK retractor with a Wollenberg laryngeal blade or a Weerda distending laryngoscope was used. A surgical assistant managed a high-definition videolaryngoscope to obtain the most appropriate view. We used a laryngeal rigid endoscope (12067VA; Karl Storz) with an Image 1 HD camera (Karl Storz) or an Endoeye Flex (Olympus Medical Systems, Tokyo, Japan), which has a flexible part at its tip (Fig. 1). The Endoeye Flex was used in the narrow band imaging mode to screen for the intraepithelial spread of cancer [16] and in the normal white light mode during surgery.

Before incision, 1.5 % iodine solution was sprayed around the tumor and the area was rinsed with physiological saline. With this procedure, intraepithelial tumor spread is clearly visible as an unstained area [13, 14]. Iodine staining

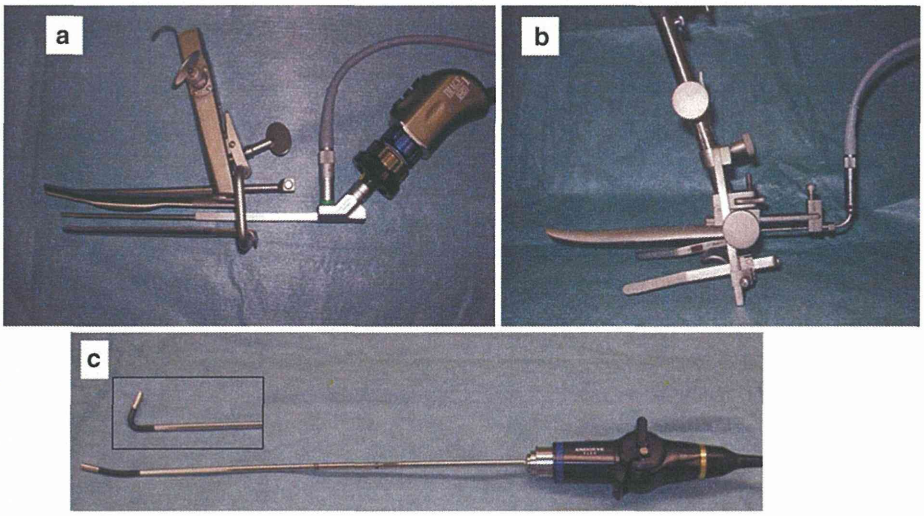

Fig. 1 **a** Weerda distending laryngoscope and videolaryngoscope with high-definition camera. **b** FK retractor with Wollenberg laryngeal blade. **c** Endoeye Flex; the tip of the endoscope is flexible

is especially effective in identifying a tumor's boundary in hypopharyngeal cancer and posterior wall oropharyngeal cancer. The mucosal incision line was set with a 5–10 mm safety margin from the iodine unstained area. For incision and dissection, the operator manipulated bimanual laparoscopic instruments such as a needle electrode (26167ND; Karl Storz), hook-type electrode (26870UF; Karl Storz), forceps (30721MD; Karl Storz), and scissors (30721 MW; Karl Storz). These instruments had a 3-mm diameter. Suction cautery (8606E; Karl Storz) or hemoclips (8665 L/R; Karl Storz) were used for hemostasis. The details of the surgical procedures are described in previous articles [13–15]. Figs. 2, 3 and 4 present representative patients.

In patients with cervical lymph node metastasis, a neck dissection was performed on the same day or within 2 weeks after TOVS. Patients without evidence of metastasis were followed up after the surgery, and a preventive neck dissection was performed in two patients since the primary tumor had invaded into the deep tissue. Patients with multiple nodal metastases, extracapsular spread, or a positive margin at the primary site were offered postoperative radiation or chemoradiation.

Patients

From September 2004 to December 2010, 60 consecutive patients with T1, T2, and selected T3 laryngeal and pharyngeal cancer were enrolled in this study. Tumor staging indicated Stage I in 17 patients, Stage II in 16 patients, Stage III in 7 patients, and Stage IV in 20 patients. The institutional review board approved the retrospective protocol of this study. The minimum follow-up period was 24 months or until the patient's death. Fifty-three patients had newly diagnosed squamous cell carcinoma of the supraglottis (9 patients), oropharynx (18 patients), or hypopharynx (26 patients). One patient had multiple cancer lesions in the laryngopharyngeal region. This patient was assigned to the oropharyngeal cancer group since the largest lesion was located in the oropharynx. Of the 53 patients receiving initial cancer treatment, 5 patients had a history of radiation on the neck for other causes. The other seven patients had recurrent squamous cell carcinoma of the supraglottis (3 patients) or hypopharynx (4 patients) after chemoradiation. Table 1 summarizes the patients' TN classification. The mean and median ages of the patients were 64.5 and 64 years, respectively (range 50–81 years). Fifty-four patients were male and six were female.

Data analysis

The overall survival rate, disease-specific survival rate, local control rate, locoregional control rate, and laryngeal preservation rate were evaluated for all TOVS patients. These rates were calculated using the Kaplan–Meier method. The censoring events of each parameter were as follows: for overall survival, all deaths; for disease-specific

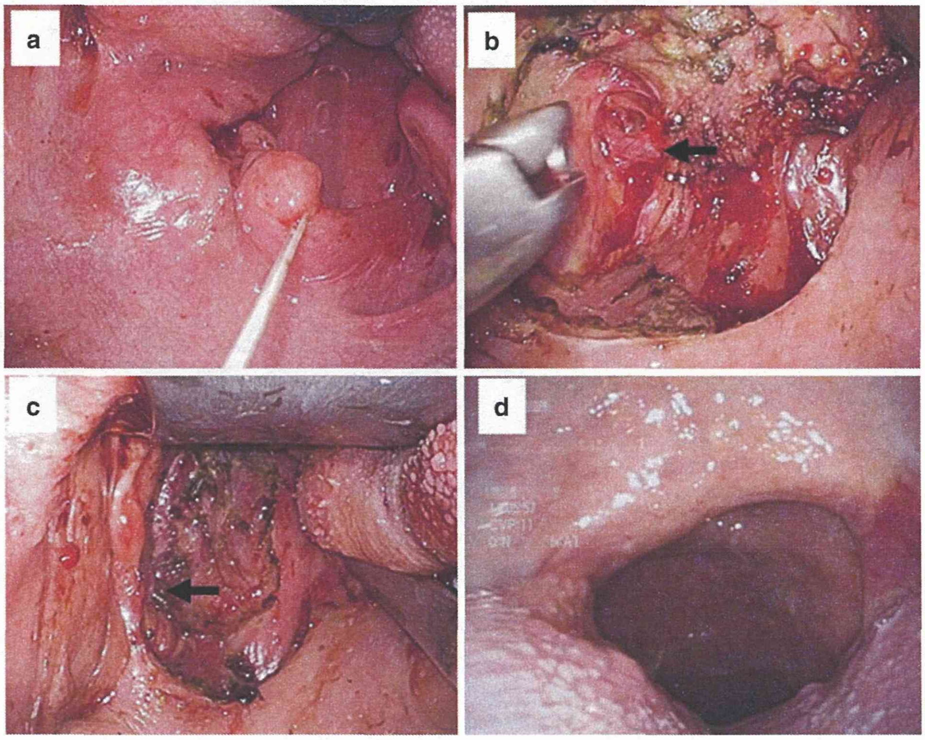

Fig. 2 TOVS for T2N0 oropharyngeal cancer. **a** The left palatine tonsil and left base of the tongue were resected en bloc. The parapharyngeal space was exposed. **b**, **c** The facial artery (*arrow*) and lingual artery were identified and clipped. **d** Postoperative findings 2 months after TOVS

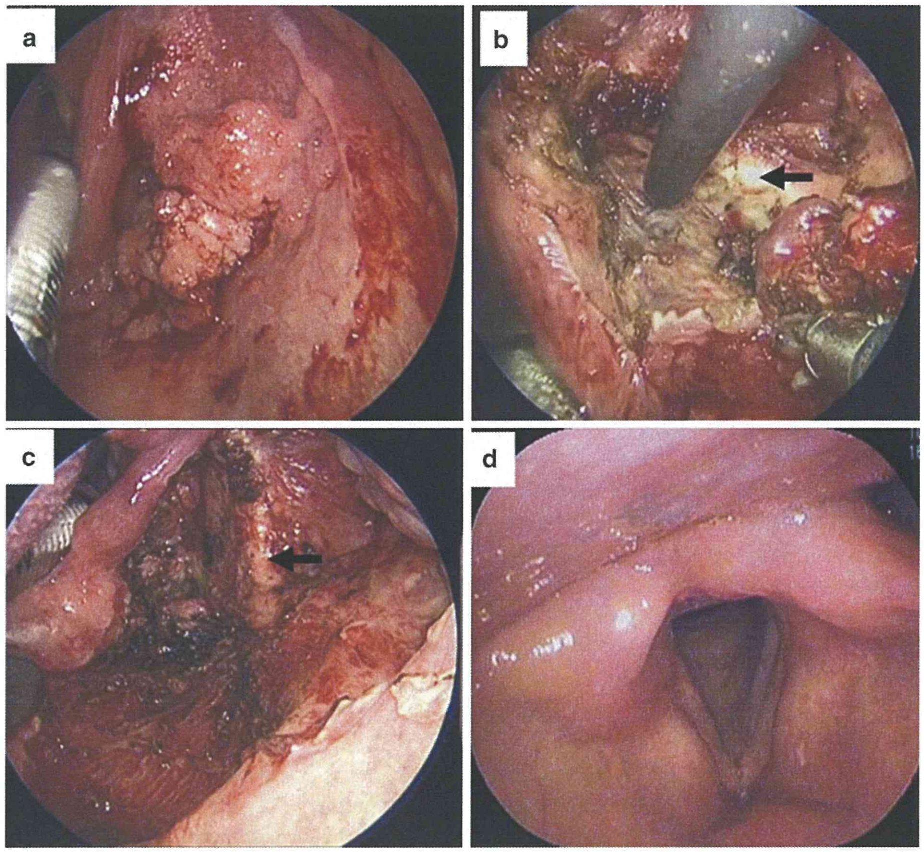

Fig. 3 TOVS for T3N0 hypopharyngeal cancer. **a** The right piriform sinus was resected en bloc. **b**, **c** The perichondrium of the thyroid cartilage (*arrow*) was exposed. **d** Stenosis of the right piriform sinus was present postoperatively, but the patient could swallow through the left piriform sinus without difficulty

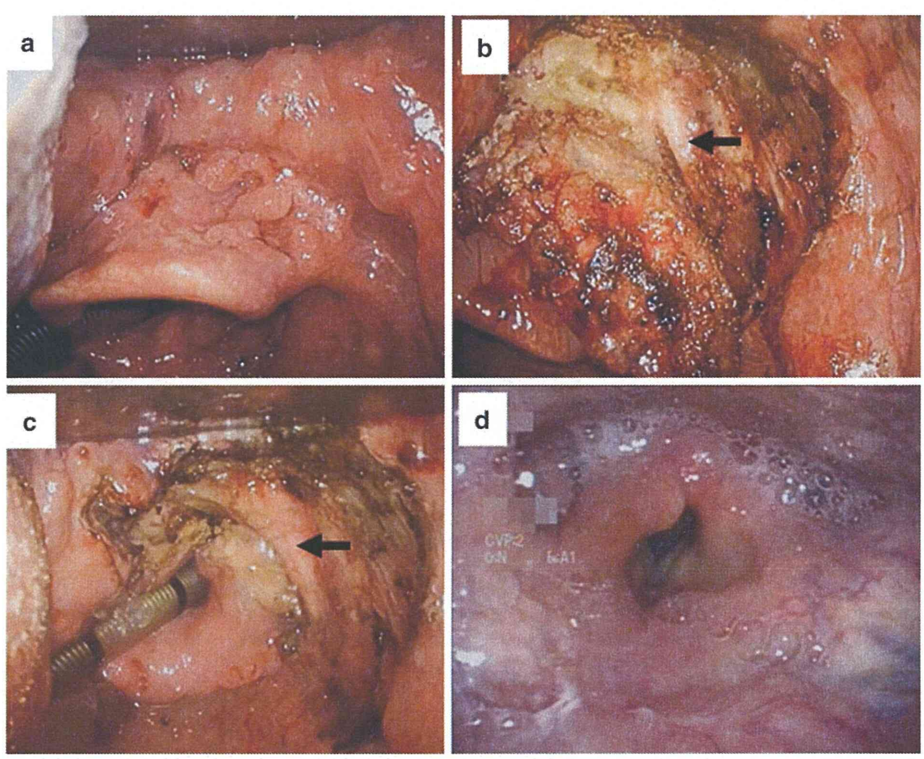

Fig. 4 TOVS for T2N2c supraglottic cancer. **a** The whole epiglottis and pre-epiglottic fat tissue were resected en bloc. **b**, **c** The hyoid bone (*arrow*) was exposed in the operative field. The patient underwent bilateral neck dissection the same day. **d** Postoperative findings 2 months after TOVS

Table 1 Patients' TN classification

Oropharynx (n = 18)				
	N0	N1	N2	N3
T1	5		2	
T2	4[a]		1	1
T3	2		3	
rT1				
rT2				
Hypopharynx (n = 30)				
	N0	N1	N2	N3
T1	6		2	
T2	7	2	5	
T3	3		1	
rT1	4			
rT2				
Supraglottis (n = 12)				
	N0	N1	N2	N3
T1	1			
T2	3		3	1
T3	1			
rT1	1			
rT2	1		1	

[a] Includes one patient with multiple lesions (in the supraglottis, oropharynx, and hypopharynx)

survival rate, TNM-related deaths; for local control rate, local relapse; for locoregional control rate, local or regional relapse; and for laryngeal preservation rate, total laryngectomy, laryngopharyngectomy, or functional loss of the larynx (i.e., dependence on a feeding tube). The data were analyzed using JMP for Windows version 9.02 (SAS Institute Inc., Cary, NC, USA).

A patient's swallowing function after treatment was evaluated by the number of days from surgery to resuming oral intake, whether the patient had percutaneous endoscopic gastrostomy (PEG) dependence, and the patient's Functional Outcome Swallowing Scale (FOSS) stage [17] [range stage 0 (normal) to stage 5 (non-oral feeding)]. The patient's FOSS stage was evaluated at 1 year after surgery or at the last visit if the follow-up period was less than 1 year.

Results

Surgical results

During the same period, TOVS was attempted but not performed in four patients because the tumor had infiltrated to the deep muscular layer (2 patients) or because of poor exposure of the tumor (2 patients). These patients underwent a different treatment option. Thus, TOVS was accomplished in 94 % of the patients. Mean and median operation times for TOVS, including frozen section diagnosis for the majority of cases, were 112 and 124 min (range 18–279 min), respectively. Neck dissections were performed as an initial treatment in 24 (40 %) patients. Seven patients also received neck dissections for delayed lymph node metastasis. Therefore, neck dissections were performed in 31 (51.6 %) patients.

Oncological results

Postoperative radiation and chemoradiation were administered to 17 and 7 patients, respectively (the radiation/chemoradiation rate was 40 %). The reasons for postoperative radiation or chemoradiation were multiple cervical lymph node metastases or extracapsular spread (13 patients), preventive intention for possible occult lymph node metastasis in T3cN0 tumor (2 patients), positive surgical margin at the primary site (5 patients), and recurrence (4 patients—3 had delayed lymph node metastasis and 1 had a recurrence at the primary site).

The median and mean follow-up periods were 48 and 49 months, respectively. For all TOVS patients, the 5-year overall survival rate was 76 %, the disease-specific survival rate was 90 %, the local control rate was 91 %, the locoregional control rate was 76 %, and the laryngeal preservation rate was 94 % (Fig. 5). The patients were categorized into an initial treatment group (n = 53) and a salvage after chemoradiation group (n = 7). For patients who underwent initial cancer treatment, the 5-year overall survival rate was 77 %, the disease-specific survival rate was 95 %, the local control rate was 94 %, the locoregional control rate was 76 %, and the laryngeal preservation rate was 96 %. Table 2 summarizes these data, which were analyzed according to the location of the tumor.

For seven patients (4 patients with hypopharyngeal cancer and 3 patients with supraglottic cancer) who underwent salvage surgery, the 5-year overall survival rate was 75 %, the disease-specific survival rate was 75 %, the local control rate was 71 %, the locoregional control rate was 71 %, and the laryngeal preservation rate was 80 %.

Functional results

The median time before patients could resume eating was 6 days (range 1–19 days) and that before patients could resume swallowing a soft diet was 9 days (range 1–89 days). At 1 year after surgery or at the patient's last visit, the FOSS stage was stage 0 in 71.6 % of the patients, stage 1 in 18.3 % of the patients, stage 2 in 3.3 % of the

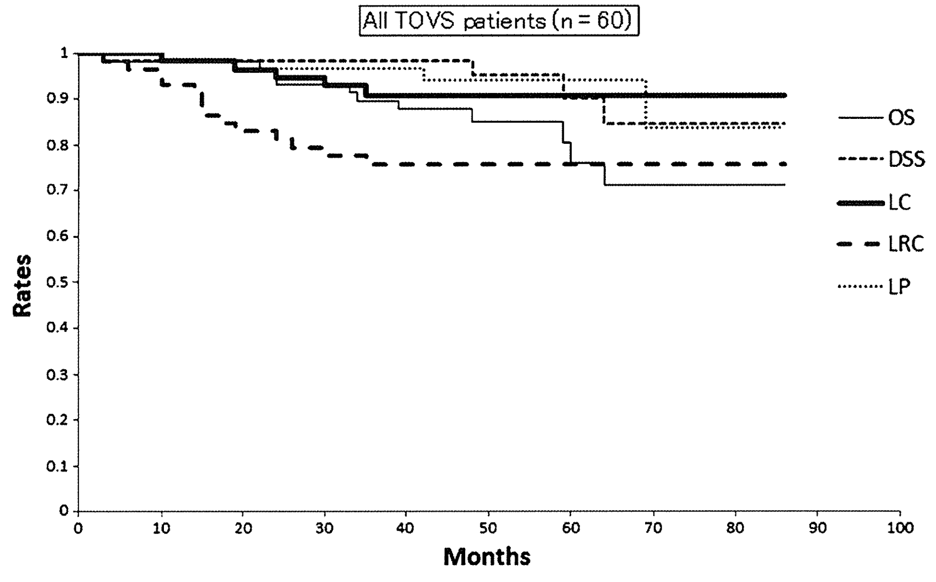

Fig. 5 Kaplan–Meier curves for all patients who underwent TOVS. *DSS* disease-specific survival, *LC* local control rate, *LP* laryngeal preservation rate, *LRC* locoregional control rate, *OS* overall survival, *TOVS* transoral videolaryngoscopic surgery

Table 2 Five-year oncological results of initial cases on the basis of tumor location

	OS (%)	DSS (%)	LC (%)	LRC (%)	LP (%)
Oropharynx ($n = 18$)	81	92	100	83	100
Hypopharynx ($n = 26$)	78	96	90	77	96
Supraglottis ($n = 9$)	78	100	89	55	89
All initial cases ($n = 53$)	77	95	94	76	96

DSS disease-specific survival rate, *LC* local control rate, *LP* laryngeal preservation rate, *LRC* locoregional control rate, *OS* overall survival rate

patients, stage 3 in 5 % of the patients, and stage 4 in 1.7 % of the patients.

No patient underwent PEG placement. However, one patient (an 81-year-old man with T1N0 hypopharyngeal cancer) died of severe pneumonia 3 months after surgery; he had a history of radiation for laryngeal cancer and low pulmonary function because of chronic bronchitis. From a retrospective point of view, PEG placement was indicated for this patient. The cause of pneumonia may have been associated with the surgery and with his predisposing respiratory status, age, and previous irradiation. The PEG indication rate in our series was therefore 1.7 % (i.e., 1 of the 60 patients).

Surgical complications

Surgical complications included tooth fracture (1 patient), postoperative pharyngeal hemorrhage (2 patients), laryngeal edema (1 patient), cervical emphysema (3 patients), persistent dysphasia (4 patients), and velopharyngeal insufficiency that required prosthesis (2 patients). Laryngeal edema occurred after the patient underwent a secondary bilateral neck dissection, which was performed 2 weeks after TOVS. The edema was thus not directly associated with the TOVS procedure.

Four (6.7 %) patients underwent a tracheostomy: in two patients, this was performed as a prophylactic measure; in one patient, it was performed for postoperative hemorrhage; and in one patient, it was carried out because of difficulty in oral intubation. All tracheostomies were placed transiently and closed soon after TOVS.

Discussion

As previously described in "Introduction", we developed our original surgical setting to facilitate en bloc tumor resection under a wide surgical field and wide surgical view. This surgical technique is applicable to tumors of the oropharynx, hypopharynx, and supraglottis, thus covering a substantial area in the head and neck region.

In the medical literature, fractional resection by TLM has been shown to achieve good oncological outcomes. We believe, however, that en bloc resection is a more reliable method for evaluating the completeness of tumor resection. Furthermore, precise pathological evaluations such as margin status, immunohistochemical analysis, tumor depth, tumor thickness, vascular invasion, and perineural invasion can be obtained from an en bloc specimen. This type of information is important for assessing a patient's need for adjuvant therapy or additional neck dissection in clinically node-negative patients. In our previous report [18], tumor

Table 3 Summary of transoral surgery for laryngopharyngeal cancers and the results of the present study (initial cases)

Author	Modality	Primary	*n*	TN classification	Stage I–II:III–IV	OS (%)	DSS (%)	LC (%)	LP (%)
Weinstein et al. [19]	TORS	OP	47	T1–4a, N0–2	0:100	82 (2 years)	90 (2 years)	–	–
Park et al. [20]	TORS	OP	39	T1–4, N0–2	33:67	96 (2 years)	–	–	–
Weinstein et al. [12]	TORS	OP	153	T1–4, N0–3	23:77	–	–	–	–
Haughey et al. [21]	TLM	OP	204	T1–4, N0–3	0:100	86 (3 years)	88 (3 years)	97 (3 years)	–
Grant et al. [22]	TLM	OP	69	T1–3, N0–2	36:64	86 (5 years)	–	94 (5 years)	–
Present study	TOVS	OP	18	T1–3, N0–3	50:50	81 (5 years)	92 (5 years)	100 (5 years)	–
Martin et al. [2]	TLM	HP	172	T1–4, N0–2	15:85	I–II 68 (5 years) III 64 IV 41	I–II 96 (5 years) III 86 IV 57	pT1 84 (5 years) pT2 70 pT3 75 pT4 57	–
Rudert and Höft [23]	TLM	HP	29	T1–4, N0–3	31:69	48 (5 years)	58 (5 years)	72	–
Vilaseca et al. [24]	TLM	HP	28	T1–4, N0–2	21:79	43 (4 years)	59 (4 years)	87	79 (4 years)
Karatzanis et al. [25]	TLM	HP	119	T1–2, N0–2	39:61	–	73 (5 years)	85 (5 years)	–
Steiner et al. [4]	TLM	HP	129	T1–4, N0–2	26:74	I–II 71 (5 years) III–IV 47	–	I–II 82 (5 years) III–IV 69	–
Park et al. [10]	TORS	HP	23	T1–4, N0–2	26:74		84 (3 years)		89 (3 years)
Present study	TOVS	HP	26	T1–T3, N0–2	50:50	78 (5 years)	96 (5 years)	90 (5 years)	96 (5 years)
Ambrosch et al. [6]	TLM	SG	48	T1–2, N0	100:0	76 (5 years)	–	92 (5 years)	97 (5 years)
Iro et al. [5]	TLM	SG	141	T1–4, N0–3	49:51	–	–	I 86 (5 years) II 75 III 75 IV 78	–
Motta et al. [26]	TLM	SG	124	T1–3, N0	85:15	T1 91 (5 years) T2 88 T3 81		T1 82 (5 years) T2 63 T3 77	T1 89 (5 years) T2 85 T3 94
Grant et al. [27]	TLM	SG	38	T1–4	37:63	85 (2 years)	80 (2 years)	97 (2 years)	97
Mendelsohn et al. [28]	TORS	SG	18	T1–T3, N0–2	–	89 (2 years)	100 (2 years)	100 (2 years)	100 (2 years)
Present study	TOVS	SG	9	T1–T3, N0–3	44:56	78 (5 years)	100 (5 years)	89 (5 years)	89 (5 years)

DSS disease-specific survival, *HP* hypopharynx, *LC* local control rate, *LP* laryngeal preservation rate, *n* number, *OP* oropharynx, *OS* overall survival, *SG* supraglottis, *TLM* transoral laser microsurgery, *TORS* transoral robotic surgery, *TOVS* transoral videolaryngoscopic surgery depth was a significant parameter for predicting lymph node metastasis, especially when it exceeded more than 1 mm. An en bloc resection is therefore ideal when making a decision for postoperative therapy.

The wide surgical view obtained by a videolaryngoscope is superior to a microscopic view, and the surgical anatomy is easily recognizable. By moving the videolaryngoscope back and forth, a surgeon can obtain wide and close-up views, as desired. New endoscopic technology such as narrow band imaging is also applicable. Narrow band imaging is a promising technology for detecting intraepithelial cancer spread [16].

The surgical view obtained during TOVS is comparable to the view obtained during TORS. In our setting, we do not have a three-dimensional view; however, this is not critical for performing the surgery. Another merit of TOVS is that the surgeon receives tactile sensations directly through the forceps and electrocautery. Tactile sensation is very important when assessing tumor infiltration to the surrounding structures.

As a new technology, surgical robots are widely distributed in the USA. However, this technology is expensive and thus may not be affordable in all countries. In our surgical setting, we do not need expensive surgical robots. Disposable equipment used during our surgery simply involves refilling a needle electrode (approximately USA $150). Other tools used in TOVS are also reusable. Compared to the cost of robotic surgery, the cost to introduce TOVS and its running costs are quite low. Therefore, many hospitals in many countries can apply this system.

The results of survival analysis in this study seem to be acceptable with a sufficient follow-up period. Regarding initial treatment cases, the 5-year overall survival rate was slightly depressed, but this resulted from other intercurrent diseases. The 5-year local control rate was 94 %, but the locoregional control rate dropped to 76 % because of delayed lymph node metastases. By performing salvage neck dissection with or without postoperative radiotherapy, most of these patients could be managed appropriately. In our case series, nodal metastasis-related death was observed only in one patient, who showed delayed development of retropharyngeal lymph node metastasis. The 5-year laryngeal preservation and disease-specific survival rates were more than 89 %, which indicated a good organ preservation rate and tumor control rate. A comparison of TOVS with other treatment modalities such as TLM or TORS is difficult since stage distribution differs throughout the medical literature [2, 4–6, 10, 12, 19–28] (Table 3). However, the survival and organ preservation rates in the present study are comparable.

TOVS was performed in seven patients as a salvage surgery for recurrent tumor after chemoradiation. During the median follow-up period of 59 months, all patients except one were alive and without disease. Failure in salvage surgery occurred in one patient who had residual supraglottic cancer after chemoradiation at a different institution. In this patient, the tumor boundary was not clearly identified because of inflammation after chemoradiation. In some patients, after chemoradiation, it is difficult to identify the tumor margin. Therefore, a relatively wide safety margin should be considered for patients with recurrent cancer compared to patients undergoing initial treatment for cancer.

Some surgical complications were observed in TOVS. However, most complications could be managed by conservative treatments. Postoperative bleeding and dysphagia were a serious problem in a few patients. In our case series, two (3.3 %) patients required reoperation for a postoperative pharyngeal hemorrhage. The rate of postoperative hemorrhage in the present study is comparable to the rate of 0–7.1 % indicated in other reports of transoral surgery [2, 4–6, 10, 12, 19–29]. Hemostasis should nevertheless be carefully confirmed after surgery.

Patients usually showed rapid recovery of their swallowing function after TOVS. In this study, the median times before patients could resume eating and swallowing a soft diet were 6 and 9 days, respectively. We usually maintained a feeding tube for several days to prevent pharyngeal perforation to the neck since the pharyngeal constrictor muscle was exposed or partially resected in most patients. In three patients, cervical emphysema occurred but no pharyngeal perforation or leakage was observed. Most (93.3 %) patients had an FOSS stage of 0–2, but 6.7 % of the patients had a FOSS stage of 3 or 4. Dysphagia resulted from miscellaneous causes such as a history of radiation/chemoradiation or additional radiation/chemoradiation; resection of the arytenoid cartilage, epiglottis, or more than two-thirds of the soft palate; age; and low pulmonary function. No single factor showed a statistically significant relationship with postoperative dysphagia (data not shown). However, patients with multiple risk factors should be managed carefully. No patient underwent PEG placement. However, from a retrospective point of view, one patient with an FOSS stage of 4 had indications for PEG placement (leading to an incidence rate of 1.7 % in the present study). The PEG dependency rate ranges from 0 to 13 % in other reports of transoral surgery [2, 4, 10, 12, 19, 20, 22, 23, 25, 27, 28]. Though a patient's postoperative swallowing function is influenced by various factors in their medical history, our results are comparable to the results of other transoral surgery techniques.

Conclusion

We performed TOVS for patients with T1, T2, and selected T3 cancers of the oropharynx, hypopharynx, and supraglottis. With a minimum follow-up period of 24 months, the survival and laryngeal preservation rates were good. The patients rapidly recovered their swallowing function postoperatively and most patients maintained a good swallowing function. TOVS could be a minimally invasive treatment option for patients with laryngeal and pharyngeal cancer. Patients' oncological outcomes and postoperative swallowing function are satisfactory when using this technique.

Acknowledgments This research was partly supported by Grants-in-aid for Scientific Research (C) from the Japan Society for the Promotion of Science, and a Health and Labor Sciences Research Grant for Clinical Cancer Research (H21-Gannrinshou-Ippan-016) from the Ministry of Health, Labor and Welfare, Japan.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Hutcheson KA, Lewin JS (2012) Functional outcomes after chemoradiotherapy of laryngeal and pharyngeal cancers. Curr Oncol Rep 14:158–165
2. Martin A, Jäckel MC, Christiansen H, Mahmoodzada M, Kron M, Steiner W (2008) Organ-preserving transoral laser microsurgery for cancer of the hypopharynx. Laryngoscope 118:398–402
3. Steiner W, Fierek O, Ambrosch P, Hommerich CP, Kron M (2003) Transoral laser microsurgery for squamous cell carcinoma of the base of the tongue. Arch Otolaryngol Head Neck Surg 129:36–43
4. Steiner W, Ambrosch P, Hess CF, Kron M (2001) Organ preservation by transoral laser microsurgery in piriform sinus carcinoma. Otolaryngol Head Neck Surg 124:58–67
5. Iro H, Waldfahrer F, Altendorf-Hofmann A, Weidenbecher M, Sauer R, Steiner W (1998) Transoral laser surgery of supraglottic cancer: follow-up of 141 patients. Arch Otolaryngol Head Neck Surg 124:1245–1250
6. Ambrosch P, Kron M, Steiner W (1998) Carbon dioxide laser microsurgery for early supraglottic carcinoma. Ann Otol Rhinol Laryngol 107:680–688
7. Steiner W, Ambrosch P (2000) Endoscopic laser surgery of the upper aerodigestive tract. Thieme, New York, pp 33–115
8. O'Malley BW Jr, Weinstein GS, Snyder W, Hockstein NG (2006) Transoral robotic surgery (TORS) for base of tongue neoplasms. Laryngoscope 116:1465–1472
9. Weinstein GS, O'Malley BW Jr, Snyder W, Sherman E, Quon H (2007) Transoral robotic surgery: radical tonsillectomy. Arch Otolaryngol Head Neck Surg 133:1220–1226
10. Park YM, Kim WS, De Virgilio A, Lee SY, Seol JH, Kim SH (2012) Transoral robotic surgery for hypopharyngeal squamous cell carcinoma: 3-year oncologic and functional analysis. Oral Oncol 48:560–566
11. Weinstein GS, O'Malley BW Jr, Snyder W, Hockstein NG (2007) Transoral robotic surgery: supraglottic partial laryngectomy. Ann Otol Rhinol Laryngol 116:19–23
12. Weinstein GS, O'Malley BW Jr, Magnuson JS et al (2012) Transoral robotic surgery: a multicenter study to assess feasibility, safety, and surgical margins. Laryngoscope 122:1701–1707
13. Shiotani A, Tomifuji M, Araki K, Yamashita T, Saito K (2010) Videolaryngoscopic transoral en bloc resection of supraglottic and hypopharyngeal cancers using laparoscopic surgical instruments. Ann Otol Rhinol Laryngol 119:225–232
14. Shiotani A, Tomifuji M, Araki K, Yamashita T (2011) Transoral videolaryngoscopic surgery for en bloc resection of supraglottic and hypopharyngeal cancers. Otolaryngol Head Neck Surg 144:288–289
15. Yamashita T, Tomifuji M, Araki K, Kurioka T, Shiotani A (2011) Endoscopic transoral oropharyngectomy using laparoscopic surgical instruments. Head Neck 33:1315–1321
16. Matsuba H, Katada C, Masaki T et al (2011) Diagnosis of the extent of advanced oropharyngeal and hypopharyngeal cancers by narrow band imaging with magnifying endoscopy. Laryngoscope 121:753–759
17. Salassa JR (1999) A functional outcome swallowing scale for staging oropharyngeal dysphagia. Dig Dis 17:230–234
18. Tomifuji M, Imanishi Y, Shiotani A et al (2011) Tumor depth as a predictor of lymph node metastasis of supraglottic and hypopharyngeal cancers. Ann Surg Oncol 18:490–496
19. Weinstein GS, O'Malley BW Jr, Cohen MA, Quon H (2010) Transoral robotic surgery for advanced oropharyngeal carcinoma. Arch Otolaryngol Head Neck Surg 136:1079–1085
20. Park YM, Kim WS, Byeon HK, Lee SY, Kim SH (2012) Oncological and functional outcomes of transoral robotic surgery for oropharyngeal cancer. Br J Oral Maxillofac Surg. pii: S0266-4356(12)00526-8
21. Haughey BH, Hinni ML, Salassa JR et al (2011) Transoral laser microsurgery as primary treatment for advanced-stage oropharyngeal cancer: a United States multicenter study. Head Neck 33:1683–1694
22. Grant DG, Hinni ML, Salassa JR, Perry WC, Hayden RE, Casler JD (2009) Oropharyngeal cancer: a case for single modality treatment with transoral laser microsurgery. Arch Otolaryngol Head Neck Surg 135:1225–1230
23. Rudert HH, Höft S (2003) Transoral carbon-dioxide laser resection of hypopharyngeal carcinoma. Eur Arch Otorhinolaryngol 260:198–206
24. Vilaseca I, Blanch JL, Bernal-Sprekelsen M, Moragas M (2004) CO_2 laser surgery: a larynx preservation alternative for selected hypopharyngeal carcinomas. Head Neck 26:953–959
25. Karatzanis AD, Psychogios G, Waldfahrer F et al (2010) T1 and T2 hypopharyngeal cancer treatment with laser microsurgery. J Surg Oncol 102:27–33
26. Motta G, Esposito E, Testa D, Iovine R, Motta S (2004) CO_2 laser treatment of supraglottic cancer. Head Neck 26:442–446
27. Grant DG, Salassa JR, Hinni ML, Pearson BW, Hayden RE, Perry WC (2007) Transoral laser microsurgery for carcinoma of the supraglottic larynx. Otolaryngol Head Neck Surg 136:900–906
28. Mendelsohn AH, Remacle M, Van Der Vorst S, Bachy V, Lawson G (2013) Outcomes following transoral robotic surgery: supraglottic laryngectomy. Laryngoscope 123:208–214
29. Salassa JR, Hinni ML, Grant DG, Hayden RE (2008) Postoperative bleeding in transoral laser microsurgery for upper aerodigestive tract tumors. Otolaryngol Head Neck Surg 139:453–459

Yokoyama *et al. Head & Face Medicine* 2014, **10**:6
http://www.head-face-med.com/content/10/1/6

HEAD & FACE MEDICINE

SHORT REPORT Open Access

Impact of removing mastoid process for advanced parotid cancer on facial nerve identification, preservation and reconstruction

Junkichi Yokoyama*, Shinichi Ooba, Mitsuhisa Fujimaki, Takashi Anzai, Masataka Kojima and Katsuhisa Ikeda

Abstract

Background: Advanced parotid cancers more than 4 cm are firmly fixed around the main trunk of the facial nerve that can be hardly detected in narrow working space between mastoid process and parotid cancer. Even though facial nerve was preserved, facial nerve stretching during surgery has significantly serious effect on postoperative facial palsy.

Objective: To evaluate usefulness of removing mastoid process in managing advanced parotid cancers to contribute identifying and preserving facial nerve.

Method: The study was performed on 18 advanced parotid cancers which was more than 4 cm and invaded around the facial nerve. Thirteen cases were fresh cases and 5 were recurrent cases.
According to a modified Blair incision, the sternocleidomastoid muscle is detached from the mastoid process with electrocautery. When the mastoid process is removed, the main trunk of the facial nerve can be observed from stylomastoid foramen.
This procedure was evaluated based on the duration of surgery, working space, and postoperative facial nerve function.

Results: In eleven cases, facial nerves were sacrificed. Negative margins were achieved in 100% of the patients. The mean duration for removing of the mastoid process to identify facial nerves was 4.6 minutes. The mean size of the removed mastoid process was 2.1 cm in height and 2.3 cm in width, and 1.8 cm in depth. The extended mean working space was 16.0 cm^3, and, as a result, the tumors could be resected without retraction.

Conclusion: Removing the mastoid process for advanced parotid tumors facilitates identification of the facial nerve and better preservation of the facial nerve function.

Keywords: Mastoid process resection, Temporal bone resection, Mastoidectomy, Advanced parotid cancer, Facial nerve preservation, Facial nerve reconstruction

Introduction

Advanced parotid cancers more than 4 cm are firmly fixed around the main trunk of the facial nerve that can be hardly detected in narrow working space between mastoid process and parotid gland with cancer. Though facial nerve is preserved, facial nerve stretching during surgery has significantly serious effect on postoperative facial palsy [1]. Parotid cancers can spread along the nerve to the temporal bone proximally. However, temporal bone surgeries for managing parotid malignancies are not well reported.

Objective

To evaluate usefulness of removing mastoid process in managing advanced or recurrent parotid cancers to contribute identifying, preserving, and reconstructing facial nerve.

Patients and method

The study was performed on 18 advanced parotid cancers of more than 4 cm and invading around the facial nerve.

* Correspondence: jyokoya@juntendo.ac.jp
Department of Otolaryngology, Head and Neck Surgery, Juntendo University School of Medicine, 2-1-1,Hongo, Bunkyo-ku, Tokyo 113-8421, Japan

Table 1 Patients and tumor characteristics

Characteristics	Number	Characteristics	Number
Gender		**Pathological type**	
Male	9	Carcinoma ex pleomorphic adenoma	4
Female	9	Salivary duct carcinoma	3
Age		Epithlial-myoepithlial carcinoma	2
Range	30-84	squamous cell carcinoma	2
Mean	59.3	Adenocarcinoma	2
Median	65	Acinic cell carcinoma	2
		others	3
Previous treatment			
Untreated	13	**HB scores**	
Recurrent	5	I	4
		II	5
Stage		III	2
III	3	IV	0
IVA	8	V	3
I'VE	7	VI	4

Thirteen cases were fresh cases and 5 were recurrent cases (Table 1).

Surgical procedure

According to a modified Blair incision, the skin flap is elevated in the superficial parotid fascia layer anteriorly to expose the mass to be resected. The parotid gland with cancer is separated from the cartilaginous external auditory canal. The sternocleidomastoid muscle is detached from the mastoid process with electrocautery. When the mastoid process is removed by large rongeur bone forceps, the main trunk of the facial nerve can be observed from stylomastoid foramen (Figure 1). The length of the cancer and mastoid process was 3 mm. The working space is very narrow. Removing mastoid process extends the working space extremely. This contributes to leveling the height between the facial nerve and the surface of the tumor, facilitating the handling of surgical instruments in the narrow working space along the facial nerve, and diminishing the tension on the facial nerve by releasing the facial canal proximally.

When the facial nerve has been already recognized as total paralysis, dissection is carried out along the main trunk of the facial nerve to the proximal intra-facial canal and distal to the cancer so that facial nerve reconstruction can be achieved after resection of the tumor. We accomplish this by removing the mastoid process and identifying the facial nerve in the vertical section of the temporal bone. Frozen examination of the proximal and distal nerve is checked prior to nerve reconstruction.

This procedure was evaluated based on the duration of surgery, working space, and postoperative facial nerve function using the House-Brackmann (HB) score [2].

Results

Eighteen patients required either mastoidectomy (n: 15) or extended temporal bone resection (n: 3). In eleven

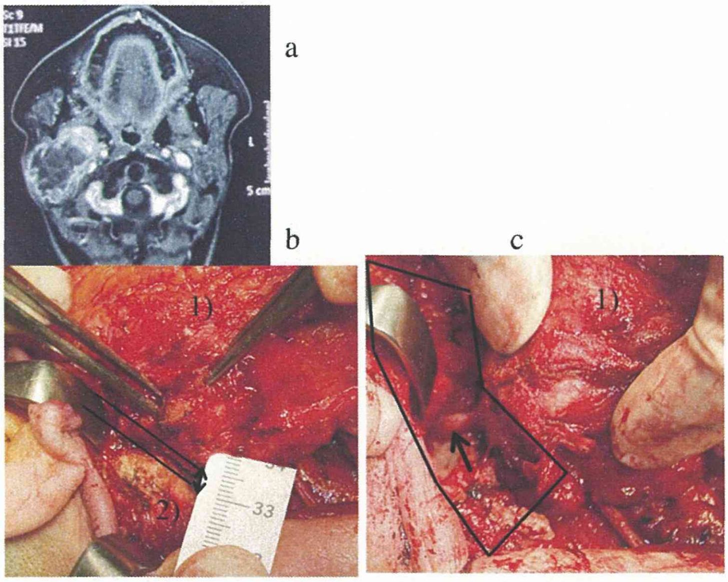

Figure 1 Recurrent parotid cancer. a). MRI. **b)**. Intraoperative findings (before removing mastoid process). Working space is significantly narrow (↔) between mastoid process and the tumor. 1) the tumor, 2) mastoid process. **c)**. After removing mastoid process. Expanding the working space facilitates identification of the facial nerve and dissection of parotid tumor without retracting the facial nerve (arrow).

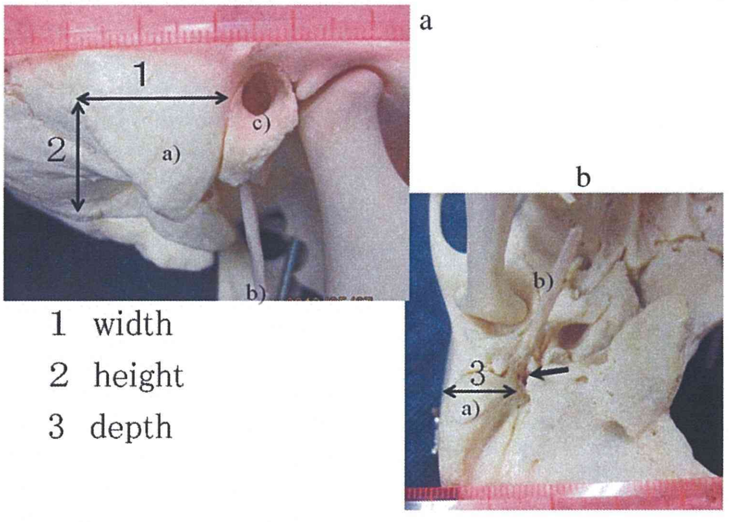

Figure 2 Anatomy of mastoid process. a. Lateral view. **b.** Inferior view a): mastoid process, b): styloid process, c): external ear.

cases, facial nerves were sacrificed. Theses facial nerves were reconstructed.

Negative margins were achieved in 100% of the patients.

The mean duration for removing of the mastoid process to identify facial nerves was 4.6 minutes (2 minutes-13 min). The mean length of the cancer and mastoid process was 4.3 mm. The mean size of the removed mastoid process was 2.1 cm in height and 2.3 cm in width, and 1.8 cm in depth (Figure 2). The extended mean working space was 16.0 cm^3,

Table 2 Surgical procedure characteristics

Characteristics	Number	Characteristics	Number
Tumor size		**Removing size of mass**	cm
Range	4 cm — 8 cm	**Height**	
Median	5.2 cm	Range	1.9-2.4
		Mean	2.1
Follow-up time	months	**Width**	
Range	8-66	Range	2.1-2.8
Median	34.9	Mean	2.3
		Depth	
Period of removing mastoid tip and identifying facial nerve	minutes	Range	1.6-2.2
Range	2-13	Mean	1.8
Mean	4.6		
		Working space	cm3
Distance between cancer and mastoid process	mm	Range	13.5-19.8
Range	2–9	Mean	16
Mean	4.3		
		postoperative HB scores	
		I	4
		II	4
		III	3
		IV	5
		V	2
		VI	0

and, as a result, the tumors could be resected without retraction (Table 2).

Preoperative each I, II, III, IV, V, and VI of H-B score was 4, 5, 2, 0, 3, 1 and 4, respectively.

Of the 7 patients in which the facial nerve was preserved, all 7 patients had almost normal facial function (HB I, II).

Discussion

Facial nerve management is a crucial component of parotid surgery. Every effort should be made to preserve the facial nerve function [3]. Removal of the mastoid process and careful dissection around the nerve in the stylomastoid foramen permits full exposure of the nerve as it passes through the facial canal. As a result, of the 7 patients in which the facial nerve was preserved, all 7 patients had almost normal facial function (HB I, II). However, according to our historical cohort (without mastoid procedure), the overall incidence of facial paralysis (HB > 1) was 100% for temporary and 20% for permanent deficits.

We indicated this mastoidectomy for locally advanced parotid cancers larger than 4 cm that invaded firmly around the parotid, recurrent large parotid cancers, and complete facial paralysis in order to identify facial nerves without stretching and maintaining surgical margins.

Tumors involving only the mastoid process can be safely managed with removal of the mastoid process. Because large rongeur bone forceps are more useful and safer than electrical burr for head and neck surgeon lacking otology technique.

When cancers involve the middle ear, removing the mastoid process and resection the temporal bone along the facial nerve facilitates resection of the middle ear cancer. Inadequate surgical margins have been reported in up to 63% of patients [4]. Positive margins have been reported poor outcomes [3]. Our study showed 100% negative margins in the patients.

This procedure enabled safe identification of the facial nerve, and facilitated reconstruction in facial nerve in patients with sacrificed facial nerves.

Conclusion

Removing the mastoid process for advanced parotid tumors facilitates identification of the facial nerve and, therefore, better preservation of the facial nerve function.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

JY conceived of the study. JYprepared and edited the manuscript. SO and MF contributed to the acquisition of data. TA and MK performed the statistical analysis. JY and KI revised the final version of the manuscript. All authors read and approved the final manuscript

Acknowledgment

This study was supported in part by a Grant for Clinical Cancer Research from the Ministry of Health, Labor, and Welfare of Japan.

Received: 16 January 2014 Accepted: 26 February 2014
Published: 3 March 2014

References

1. Dulguerov P, Marchal F, Lehmann W: **Postparotidectomy facial nerve paralysis: possible etiologic factors and results with routine facial nerve monitoring.** *Laryngoscope* 1999, **109**:(5:754–762).
2. House JW, Brackma DE: **Facial nerve grading system.** *Otolaryngol Head Neck Surg* 1985, **93**(2):146–147.
3. Iyer NG, Clark JR, Murali R, Gao K, O'Brien CJ: **Outcomes following parotidectomy for metastatic squamous cell carcinoma with microscopic residual Disease: implications for facial nerve preservation.** *Head Neck* 2009, **31**(1):21–27.
4. Garden AS, El-Naggar AK, Morrison WH, Callender DL, Ang KK, Peters LJ: **Postoperative radiotherapy for malignant tumors of the parotid gland.** *Int J Radiat Oncol Biol Phys* 1997, **37**(1):79–85.

doi:10.1186/1746-160X-10-6
Cite this article as: Yokoyama *et al.*: Impact of removing mastoid process for advanced parotid cancer on facial nerve identification, preservation and reconstruction. *Head & Face Medicine* 2014 **10**:6.

Journal of Cranio-Maxillo-Facial Surgery xxx (2014) 1–4

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Impact of indocyanine green fluorescent image-guided surgery for parapharyngeal space tumours

Junkichi Yokoyama*, Shinichi Ooba, Mitsuhisa Fujimaki, Takashi Anzai, Ryota Yoshii, Masataka Kojima, Katsuhisa Ikeda

Department of Otolaryngology-Head and Neck Surgery, Juntendo University School of Medicine, Tokyo, Japan

A R T I C L E I N F O

Article history:
Paper received 1 June 2013
Accepted 13 December 2013

Keywords:
Indocyanine green (ICG)
Navigation surgery
Parapharyngeal space tumours
Head and neck cancer
Robotic surgery
Endoscopic surgery
Minimally invasive surgery

A B S T R A C T

In parapharyngeal space dissection, significant complications such as dysphagia and carotid artery rupture have been reported. In order to resect tumours safely in narrow parapharyngeal space, we propose indocyanine green (ICG) florescence image for navigation surgery.

Objective: To evaluate the usefulness of ICG fluorescent image-guided surgery for parapharyngeal space tumours.

Methods: 0.5 mg/kg of ICG was injected via the cephalic vein. Observation of the fluorescent image was performed with HEMS (HyperEye Medical System) at 10–30 min after injection. At first, the position of the tumour was marked over pharyngeal mucosa according to ICG fluorescence imaging with HEMS. We also confirmed submucosal tumours hidden under fascia using HEMS imaging again and resected them.

Results: All tumours displayed bright fluorescence emissions which clearly contrasted with the normal structures. Even with the submucosal tumour covered with and obscured by fasciae, we could observe the tumour clearly under HEMS imaging. Tumours behind the carotid artery and lower cranial nerves also were displayed bright fluorescence emissions and were clearly detected. As a result, we could completely remove the tumour safely and noninvasively to preserve pharyngeal functions.

Conclusion: ICG fluorescence imaging is effective for the detection and resection of the parapharyngeal space tumours with preserving functions.

1. Introduction

In the dissection of the narrow parapharyngeal space, it is very difficult to resect tumours without complications such as dysphagia and carotid artery rupture (Carrau et al., 1990). In order to minimize surgical complications and preserve organs, endoscopic, or robotic surgery is often performed when conducting head and neck surgery. However, it is impossible to physically palpate tumours or to observe diffusely invaded deep organs during these procedures. In order to resect tumours safely in these cases, we propose using ICG florescence for navigation surgery in parapharyngeal space tumour resection.

1.1. Objective

To evaluate the usefulness of ICG fluorescent image-guided surgery for parapharyngeal space tumours.

* Corresponding author. Department of Otolaryngology-Head and Neck Surgery, Juntendo University School of Medicine, Hongo 3-1-1, Bunkyo-ku, Tokyo 113-8421, Japan. Tel.: +81 3 3813 3111; fax: +81 3 5840 7103.
E-mail address: jyokoya@juntendo.ac.jp (J. Yokoyama).

2. Material and methods

Six patients were included within this study. There were 4 pharyngeal cancer cases and 2 other cases. The numbers of primary cancers and lymph node metastasis were 1 and 5, respectively. Untreated cases and recurrent cases were 4 and 2, respectively. Squamous cell carcinoma and others were 4 and 2, respectively (Table 1). All cases were scored according to NIR Fluorescence Imaging Visibility Score (Poellinger et al., 2011) from 0 to 5.

0.5 mg/kg of ICG was injected via the cephalic vein. Observation of the fluorescent image was conducted with HEMS at 30–60 min after injection. Initially the position of the tumour was marked on the pharyngeal mucosa according to ICG fluorescence imaging guide in hypopharyngeal cancer (Fig. 1a,b). We then incised the pharyngeal mucosa transorally (Fig. 2a). We confirmed the submucosal tumour obscured by fascia under HEMS imaging again (Fig. 2b). When we detected the position of the tumour obscured by fascia, we could then safely visualize the tumour by removing the fasciae. Consequently, we could confirm the proximity of the tumour to the carotid artery and lower cranial nerves, and thus

1010-5182/$ – see front matter © 2013 European Association for Cranio-Maxillo-Facial Surgery. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jcms.2013.12.001