

ORIGINAL ARTICLE

Oncologic safety of cervical nerve preservation in neck dissection for head and neck cancer

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Abstract

Background: Although the functional merits of preserving cervical nerves in neck dissection for head and neck cancer have been reported, the oncologic safety has not yet been determined. Therefore, the purpose of this study was to evaluate the safety of cervical nerve preservation.

Methods: A retrospective chart review was performed on patients with head and neck cancer who had been treated by neck dissection between 2009 and 2014 at Kyoto Medical Center. Management of cervical nerves and clinical results were analyzed.

Results: A total of 335 sides of neck dissection had been performed in 222 patients. Cervical nerves were preserved in 175 neck sides and resected in 160 sides. The 5-year overall survival (OS) rate calculated by the Kaplan-Meier method was 71%. The 5-year neck control rate was 95% in cervical nerve preserved sides and 89% in cervical nerve resected sides.

Conclusion: Preserving cervical nerves in neck dissection is oncologically safe in selected cases.

KEYWORDS

cervical nerve, head and neck cancer, neck dissection, oncologic safety, preservation

1 | INTRODUCTION

Head and neck cancer often metastasizes to cervical lymph nodes. It is well known that the presence of cervical lymph node metastasis is a powerful negative prognostic factor of head and neck cancer, and its control is essential for good treatment outcomes.^{1,2} Neck dissection plays a central role in the treatment of head and neck squamous cell carcinoma and is the most effective treatment measure for neck metastases. Radical neck dissection (RND) was first reported by Crile³ as a systematic surgical method for cervical metastases in 1906, and became widely recognized after the detailed report by Martin et al⁴ in 1951. In RND, the structures adjacent to cervical lymphoadipose tissue are resected as widely as possible.

The effectiveness of RND as a curative treatment has been demonstrated in many clinical reports.^{1,2,5} At the same time, however, increasing attention has been paid to the potential postoperative

disabilities resulting from this invasive procedure.⁶ Sequelae after neck dissection include difficulty in raising the arm, shoulder pain, difficulty in neck flexion, and cervical anesthesia. These complications are mostly permanent and significantly reduce the quality of life of the patient. Therefore, many efforts have been made to minimize the invasiveness of RND. Bocca et al⁷ showed that, since the 1960s, in selected cases, it has become possible to preserve part or all of sternocleidomastoid muscle, internal jugular vein, and spinal accessory nerve without compromising the curability of RND. This less invasive method of neck dissection, which is currently called modified radical neck dissection, is currently frequently performed in cases without extracapsular invasion of metastatic nodes. In particular, there are many studies reporting that preservation of the spinal accessory nerve reduces tightness and pain of the neck and shoulders after neck dissection.⁸⁻¹⁰

Recently, it has been reported that preservation of cervical nerves in neck dissection is effective at reducing postoperative morbidity, and,

therefore, improves the patient's postoperative quality of life.^{11,12} The anterior branches of the first to fourth cervical nerve comprise the nerve plexus in the lateral part of the neck. Cutaneous and muscular branches are outputted from cervical nerves, the former of which lead to cervical skin, and the latter to cervical and shoulder muscles, such as the trapezius muscle. Neural communication occurs between the accessory nerve and cervical nerves.¹³ It has been also reported that cervical nerves contain motor fibers that lead to the trapezius muscle.^{14,15} In neck dissection, the cervical nerves deriving from C2 to C4 are exposed. Most of their branches run laterally to the internal jugular vein, from deep to superficial, piercing the cervical lymphoadipose tissue.

In the preservation of cervical nerves, the partial cutting of the fascial layer covering lymphoadipose tissue is unavoidable. Historically, disruption of the fascial layer has been proposed as a risk factor for tumor dissemination. Therefore, it has been recommended that cervical nerves should be resected to maintain the oncologic safety of neck dissection. However, at present, the possibility of cervical nerve preservation is being discussed as a new approach in functional preservation. The merits of preserving cervical nerves have been demonstrated in some studies. Dilber et al¹¹ reported that cervical sensation recovered to normal in 58.8% of patients whose cervical nerves had been preserved in neck dissection, whereas no recovery was observed in patients whose cervical nerves were resected. Roh et al¹² reported that preservation of the cervical nerves had reduced shoulder and neck discomfort after neck dissection, improving patients' quality of life. However, there have been no reports on the oncologic safety outcomes of cervical nerve preservation. Therefore, an evaluation of cervical nerve preservation safety and appropriate indications is required.

Therefore, the purpose of this retrospective chart review was to evaluate the oncologic safety of preserving cervical nerves in neck dissection in selected patients with head and neck cancer.

2 | MATERIALS AND METHODS

This study was approved by the institutional review board of Kyoto Medical Center.

A retrospective chart review was performed on patients with head and neck cancer for whom neck dissection was performed as a curative treatment between 2009 and 2014 at Kyoto Medical Center. The American Joint Committee on Cancer TNM classification system was used to determine the cancer stages. In the analysis of cancer of unknown origin, nodal status was categorized according to the TNM system used for oropharyngeal cancer. The disease was considered to be stage III when nodal status was N1, and stage IV at N2-3. Each side of the neck was counted and evaluated separately. Neck sides where super-selective neck dissection had been performed were excluded from this analysis. The database included information regarding patient characteristics, intent of neck dissection, cervical nerve manipulation, pathological results of resected lymph nodes, presence or absence of extracapsular spread (ECS) of metastatic nodes, and cervical recurrence in the treated neck.

TABLE 1 Patient characteristics

Characteristic	Mean	Range
Age, year	66	27–90
Observation period, month	39	2–84
	No. of patients	%
Sex		
Male	167	75.2
Female	55	24.8
Disease site		
Oral	110	49.5
Hypopharynx	40	18.0
Oropharynx	27	12.1
Larynx	25	11.2
Origin unknown	7	3.2
Sinonasal	5	2.3
External auditory canal	4	1.8
Salivary gland	3	1.4
Facial skin	1	0.5
Stage		
IV	125	56.3
III	50	22.5
II	37	16.6
I	7	3.2
0	3	1.4

Neck dissection performed for neck sides clinically negative for lymph node metastasis (cN-negative neck) was categorized as “elective” dissection, whereas neck dissection for neck sides clinically positive for metastasis (cN-positive neck) was defined as “therapeutic” dissection. Pathological results of removed lymph nodes were analyzed independently on each side of the neck. When metastases were determined pathologically, the neck was classified as pN-positive, and when not, it was a pN-negative neck. Cervical nerves were considered to be “preserved” when all roots were saved in surgery and “resected” when all or part of the roots were removed. Overall survival (OS) rates and disease-free survival (DFS) rates were estimated using the Kaplan-Meier method. Neck control rates were also calculated with the Kaplan-Meier method, each dissected neck was counted separately. Pairwise comparison between plotted curves was performed using the log-rank test. A *P* value < .05 was considered statistically significant. Statistical analysis was performed with StatMate IV software (Atoms, Tokyo, Japan).

3 | RESULTS

Table 1 shows patient characteristics. A total of 222 patients were included in this study, among which 167 were men and 55 were women. Mean age at diagnosis was 66 years (range 27–90 years) and the median observation period was 1010 days (range 56–2562 days). The primary site was oral in 110 patients, hypopharynx in 40, oropharynx in 27, larynx in 20, and other sites in 20 patients. Stage of disease was IV in 125 patients, III in 50, II in 37, I in 7, and 0 in 3 patients. Neck dissection had been performed bilaterally in 113 patients and

TABLE 2 Disease features

	cN0	cN1-3	
No. of patients	76	146	
No. of neck dissections, sides	99	236	
Intent of neck dissection	Elective	Therapeutic	
No. of neck dissections, sides	99	43	193
Range of neck dissections, sides			
Levels I-V	31	16	172
Levels II-V	4	2	5
Levels I-IV	10	4	9
Levels II-IV	21	4	3
Levels I-III	33	17	4
Cervical nerve status, sides (%)			
Preserved	80 (80.8)	34 (79.1)	61 (31.6)
Resected	19 (19.2)	9 (20.9)	132 (38.4)
pN status, sides (%)			
Positive	9 (9.0)	6 (14.0)	135 (70.0)
Negative	90 (91.0)	37 (86.0)	58 (30.0)
ECS, sides (%)			
Positive	0 (0)	0 (0)	60 (31.1)
Negative	99 (100)	43 (100)	133 (68.9)
Cervical recurrence, sides (%)			
Positive	1 (1.0)	2 (4.7)	18 (9.3)
Negative	98 (99.0)	41 (95.3)	175 (90.7)

Abbreviations: ECS, extracapsular spread; pN, pathologically determined metastases.

unilaterally in 109 patients during the course of curative treatment. Therefore, a total of 335 sides of the neck were dissected.

Table 2 presents the disease features. In the 76 patients with cN0 disease, 99 sides of elective neck dissections were performed. In the 146 patients with cN1-3 disease, 236 sides of neck dissections were performed, comprising 43 sides of elective neck dissection for cN-negative necks and 193 sides of therapeutic dissections for cN-positive necks. Among 142 cN-negative neck sides dissected electively, 15 sides were proved to be pN-positive, whereas among 193 cN-positive neck sides dissected therapeutically, 135 sides were pN-positive. Among the dissected cN-negative neck sides, no cases of ECS were determined pathologically in pN-positive necks (0/15), whereas among

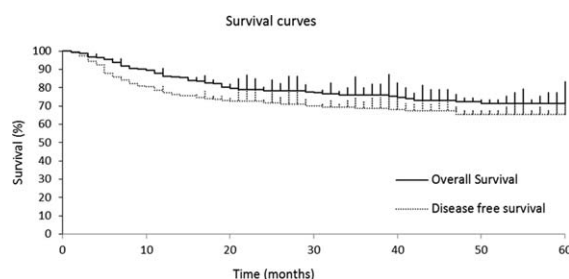


FIGURE 1 Overall survival rate curve and disease-free survival curve estimated by the Kaplan-Meier method

the dissected cN-positive neck sides, ECS was present in 44% of pN-positive necks (60/135). Overall, cervical nerve roots were preserved in 52% of dissected neck sides (175/335), and partially or completely resected in 48% (160/335). The preservation rate was as high as 80% (114/142) in the neck sides dissected electively and as low as 32% (61/193) in the neck sides dissected therapeutically. Table 3 shows the rate of cervical nerve preservation by cN status. The preservation rate was the highest in cN0 cases and decreased as the cN stage increased.

Cervical recurrence in treated neck sides occurred in 21 neck sides of 15 patients, including 8 with cervical nerve preserved sides and 13 with cervical nerve resected sides. The OS and DFS curves are shown in Figure 1: the 5-year OS and DFS rates were 71% and 66%, respectively. DFS curve by disease stage is shown in Figure 2. The DFS rate at 5 years was 100% for stage 0-I, 89% for stage II, 78% for stage III, and 59% for stage IV. Figure 3 presents the neck control rates; the 5-year control rate was 95% in cervical nerve preserved neck sides and 89% in cervical nerve resected neck sides at 5 years (log-rank, $P = .19$).

4 | DISCUSSION

It is theoretically possible for the preservation of cervical nerves to adversely affect clinical outcomes. However, to the best of the author's knowledge, there have been no reports investigating this risk. This retrospective chart study evaluated the oncologic safety of cervical nerve preservation in neck dissection for head and neck cancer.

The findings revealed that cervical nerves were preserved in 52% of neck dissections with a satisfactory OS and DFS rate. DFS rate by disease stage was comparable to previously reported clinical results

TABLE 3 Rates of cervical nerve preservation by cN status

cN status	No. of patients	Rate of cervical nerve preservation, sides (%)		
		Therapeutic neck dissection side	Elective neck dissection side	Total
cN0	76	–	80/99 (81)	80/99 (81)
cN1	45	26/45 (58)	14/17 (82)	40/62 (65)
cN2a	4	1/4 (25)	1/1 (100)	2/5 (40)
cN2b	45	11/45 (24)	18/23 (78)	29/68 (43)
cN2c	45	23/89 (26)	–	23/89 (26)
cN3	7	0/10 (0)	1/2 (50)	1/12 (8)
Total		61/193 (32)	114/142 (80)	175/335 (52)

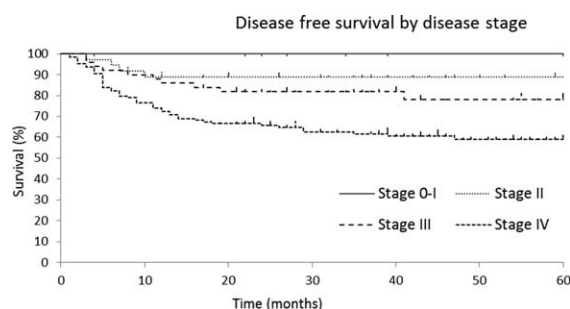


FIGURE 2 Disease-free survival curve by disease stage

and there were no signs of cervical nerve preservation-related adverse effects.^{16,17} Therefore, it can be implied that the preservation of cervical nerves is feasible, at least in selected cases. Esclamado and Carroll¹⁸ reported that cervical nerve invasion by metastatic node is rare and, when present, it is grossly apparent preoperatively. However, even without direct invasion in the cervical nerves, the presence of ECS of metastatic nodes is a factor against preserving cervical nerves. The reason for this is that, in the presence of ECS, dissemination of tumor cells can occur when the lymph nodes are roughly exposed in the surgical field. In contrast, in the absence of ECS, partial exposure of the nodal capsule may not adversely affect the curability of neck dissection as long as the capsule itself remains intact during the surgery.

In the current study, pathologic examination showed no ECS in metastatic nodes resected by elective neck dissection. This suggests that the preservation of cervical nerves can be performed safely in elective neck dissection for occult nodal metastases. In fact, the rate of cervical nerve preservation was as high as 80% (114/142 necks) in elective neck dissections. In contrast, the rate was as low as 31.6% (61/193) in therapeutic neck dissections; this was due to our intention of securing the curability of the dissection in the presence of metastatic nodes. Most of the cervical-nerve preserved neck sides were clinically negative for nodal metastases in level IIB/III/IV/V areas. Furthermore, ECS was rare in these sides.

In general, it is recommended to proceed with functional neck dissection from the lateral to the medial side of the neck, dissecting the carotid sheath in the last part of the procedure.^{19,20} However, when the preservation of cervical nerves is planned, the authors usually perform neck dissection from the medial part along the carotid artery to the lateral part of the neck. In this way, the cervical nerves are identi-

fied at their root portion, and then dissected out toward their peripherals. Importantly, lymph nodes superficial to the carotid sheath are dissected before exposing the cervical nerves; this is beneficial for reducing the risk of tumor dissemination during cervical nerve manipulation. In addition, the feasibility of cervical nerve preservation can be evaluated intraoperatively according to the surgical and/or pathological findings of the lymph nodes. If there is a sign that ECS is present, preservation of cervical nerves is relinquished and a more extensive approach is chosen.

Based on these findings, it can be proposed with high confidence that the best indication for preservation of cervical nerves is elective neck dissection, particularly in cN0 cases. In addition, a likely indication for preserving cervical nerves in therapeutic dissection is a neck side in which the metastatic nodes are confined in level I to IIA areas without any signs of ECS. A case with the presence of metastatic nodes in the course of cervical nerves in levels IIB, III, and IV is considered to be unsuitable for cervical nerve preservation.

5 | CONCLUSION

In this retrospective analysis, preservation of cervical nerves in neck dissection was shown to be possible without losing curability in selected cases. Elective neck dissection against occult neck metastases is the best indication for cervical nerve preserving surgery. More careful approaches should be adopted in therapeutic neck dissection. The likely indication is cN1 disease in which the metastatic node is located in the level I to IIA areas. Although more experience and knowledge should be accumulated based on long-term observations, cervical nerve-preserving neck dissection is a promising approach for the minimization of the surgical invasiveness of neck dissection for head and neck cancer.

REFERENCES

- [1] Shah JP, Medina JE, Shaha AR, Schantz SP, Marti JR. Cervical lymph node metastasis. *Curr Probl Surg*. 1993;30(3):1-335.
- [2] Shah JP. Cervical lymph node metastases—diagnostic, therapeutic, and prognostic implications. *Oncology (Williston Park)*. 1990;4(10): 61-69; discussion 72, 76.
- [3] Crile G. Landmark article Dec 1, 1906: Excision of cancer of the head and neck. With special reference to the plan of dissection based on one hundred and thirty-two operations. By George Crile. *JAMA*. 1987;258(22):3286-3293.
- [4] Martin H, Del Valle B, Ehrlich H, Cahan WG. Neck dissection. *Cancer*. 1951;4(3):441-499.
- [5] Khaffi RA, Gelbfish GA, Asase DK, Tepper P, Atte JN. Modified radical neck dissection in cancer of the mouth pharynx, and larynx. *Head Neck*. 1990;12(6):476-482.
- [6] Ferlito A, Rinaldo A, Silver CE, et al. Neck dissection: then and now. *Auris Nasus Larynx*. 2006;33(4):365-374.
- [7] Bocca E, Pignataro O, Oldini C, Cappa C. Functional neck dissection: an evaluation and review of 843 cases. *Laryngoscope*. 1984;94(7): 942-945.
- [8] Leipzig B, Suen JY, English JL, Barnes J, Hooper M. Functional evaluation of the spinal accessory nerve after neck dissection. *Am J Surg*. 1983;146(4):526-530.

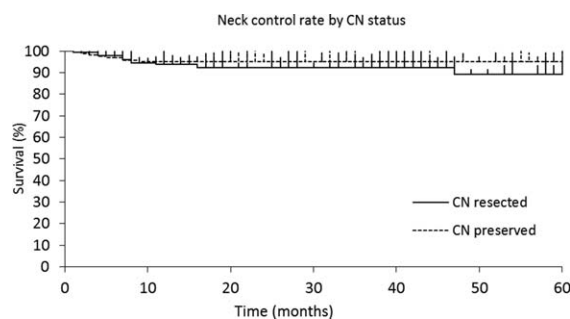
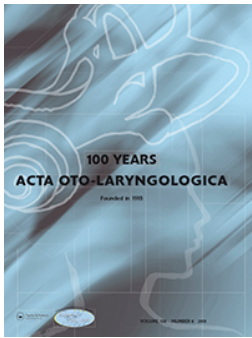


FIGURE 3 Neck control rate by cervical nerve (CN) status

- [9] Short SO, Kaplan JN, Laramore GE, Cummings CW. Shoulder pain and function after neck dissection with or without preservation of the spinal accessory nerve. *Am J Surg*. 1984;148(4):478–482.
- [10] Terrell JE, Welsh DE, Bradford CR, et al. Pain, quality of life, and spinal accessory nerve status after neck dissection. *Laryngoscope*. 2000;110(4):620–626.
- [11] Dilber M, Kasapoglu F, Erisen L, Basut O, Tezel I. The relationship between shoulder pain and damage to the cervical plexus following neck dissection. *Eur Arch Otorhinolaryngol*. 2007;264(11):1333–1338.
- [12] Roh JL, Yoon YH, Kim SY, Park CI. Cervical sensory preservation during neck dissection. *Oral Oncol*. 2007;43(5):491–498.
- [13] Saylam CY, Orhan M, Aktan Ikiz ZA, Uçerler H, Zileli M. Connection types between the spinal root of the accessory nerve and the posterior roots of the C2–C6 spinal nerves. *Surg Radiol Anat*. 2009;31(6):419–423.
- [14] Pu YM, Tang EY, Yang XD. Trapezius muscle innervation from the spinal accessory nerve and branches of the cervical plexus. *Int J Oral Maxillofac Surg*. 2008;37(6):567–572.
- [15] Tubbs RS, Shoja MM, Loukas M, et al. Study of the cervical plexus innervation of the trapezius muscle. *J Neurosurg Spine*. 2011;14(5):626–629.
- [16] Shah JP, Gil Z. Current concepts in management of oral cancer---surgery. *Oral Oncol*. 2009;45(4-5):394–401.
- [17] Hoffman HT, Karnell LH, Shah JP, et al. Hypopharyngeal cancer patient care evaluation. *Laryngoscope*. 1997;107(8):1005–1017.
- [18] Esclamado RM, Carroll WR. Extracapsular spread and the perineural extension of squamous cell cancer in the cervical plexus. *Arch Otolaryngol Head Neck Surg*. 1992;118(11):1157–1158.
- [19] Gavilán J, Herranz J, Martín L. Functional neck dissection: the Latin approach. *Oper Tech Otolaryngol Head Neck Surg*. 2004;15(3):168–175.
- [20] Khafif A. Lateral neck dissection. *Oper Tech Otolaryngol Head Neck Surg*. 2004;15(3):160–167.

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Sensory preservation in neck dissection: outcomes of a sub-sternocleidomastoid approach

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RESEARCH ARTICLE



Sensory preservation in neck dissection: outcomes of a sub-sternocleidomastoid approach

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ABSTRACT

Objective: Cutaneous anesthesia in early postoperative period is common after neck dissection even if the cervical nerve (CN) rootlets are preserved. The aim of this study was to evaluate if the preservation of the terminal branches of CNs using sub-sternocleidomastoid (SCM) approach combined with medially placed skin incision can prevent early postoperative anesthesia.

Material and methods: A retrospective chart review was performed on 129 neck dissections in 87 head and neck cancer patients.

Results: The early postoperative sensory preservation rates for the ear tab, submandibular, lateral neck, and sub-clavicular areas of CN rootlet-preserved necks ($n = 86$) were 75.6%, 20.9%, 74.4%, and 86.0%, respectively, compared with 37.2%, 2.3%, 2.3%, and 4.7%, respectively, in CN rootlet-resected necks ($n = 43$). In CN rootlet-preserved necks, the sub-SCM approach ($n = 54$) showed 81.5%, 27.8%, 92.6%, and 94.4% preservation rates, respectively, compared with 65.6%, 9.4%, 43.8%, and 71.9%, respectively, using the conventional subplatysmal approach ($n = 32$). The rates were significantly better in the submandibular, lateral neck, and sub-clavicular areas after sub-SCM approach.

Conclusions: Preservation of CN rootlets is a required element for sensory preservation in neck dissection. The sub-SCM approach can effectively prevent early postoperative cutaneous anesthesia following CN-preserving neck dissection.

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KEYWORDS

Sensory outcome; neck dissection; preservation; cervical nerve; sub-sternocleidomastoid approach

Introduction

Head and neck cancer often spreads to the cervical lymph nodes. Moreover, the presence of cervical lymph node metastasis is a strong negative prognostic factor and its control is essential for good treatment outcomes [1,2]. Radical neck dissection (RND) is the gold standard surgical treatment for cervical metastases. Many structures that are situated close to lymphoadipose tissue, such as sternocleidomastoid muscle (SCM), spinal accessory nerve (SAN), and cervical nerves (CNs), are routinely sacrificed as safety margins in RND [1–3]. Extended resection has been considered crucial to the therapeutic success of RND; however, it is typically accompanied by severe sequelae, such as difficulty in raising the arm, shoulder pain, and cutaneous anesthesia. This significantly affects the patient's quality of life [4]. In recent years, advancements in clinical oncology have reduced the invasiveness of RND [5], such as using a modified-RND (MRND) that preserves the SAN. This has greatly improved postoperative motor function in the neck and shoulder [6].

CNs are the main sensory channel in neck. Previous studies have shown that the rate of cutaneous anesthesia after sacrificing the CN rootlets can range from 65% to

100% [7–9]. While preservation of CNs has been a lower priority when compared with SAN preservation, it is possible using current techniques. Oncologically safe indications for CN preservation include elective neck dissection against occult neck metastases and cN1 disease in which the metastatic node is located at levels I–IIA [10]. A recent survey by the American Head and Neck Society revealed that 211 out of 283 surgeons only ‘rarely’ or ‘sometimes’ sacrifice the CN rootlets in neck dissection [11].

Early postoperative cutaneous sensation is the most straightforward sensory outcome to assess after neck dissection because it is not affected by other factors, such as neural regrowth and postoperative irradiation. However, studies have found that rates of early postoperative cervical anesthesia are high even with the preservation of CN rootlets [8,9,12]. It is likely that this is caused by injury to the terminal branches of the CNs during the skin incision and subplatysmal dissection method that is used in conventional neck dissection [8,12]. To the best of our knowledge, this is the first study to propose a solution to this technical deficit in neck dissection.

The aim of this study was to verify the favorable outcome of using a sub-SCM approach on early postoperative cutaneous sensation. In addition, we sought to confirm the

fundamental importance of CN rootlets in sensory preservation following neck dissection.

Material and methods

Study design and patient population

A retrospective cohort study was performed comprising patients with head and neck cancer who had undergone neck dissection as part of a curative treatment course between 2012 and 2014 at Kyoto Medical Center. This study was approved by the institutional review board (IRB). The requirement for written consent was waived by the IRB due to the retrospective, non-invasive, personally unidentifiable nature of the study. Instead, the study details were announced in written form on the public announcement board at Kyoto Medical Center.

Patients with thyroid cancer were excluded from the study because the surgical strategy differs greatly from other head and neck cancers. Patients who could not undertake sensory evaluation within 1 week of neck dissection due to poor wound or systemic conditions were also excluded. Each side of the neck was counted separately. Neck sides in which CN rootlets had been partially preserved or super-selective neck dissection had been performed were excluded to aid with clear data interpretation. The database included information regarding patient characteristics, neck dissection range, skin incision and flap dissection mode, status of CN rootlets, and sensory outcomes.

Sub-SCM approach

In this study, we adopted a 'sub-SCM approach' for CN-preserving neck dissection to prevent early postoperative cutaneous anesthesia by preserving the terminal branches of the CNs. In this approach, a skin incision is placed medial to the anterior edge of the SCM. Following skin incision, a subplatysmal dissection is performed over sub-mandibular area if necessary. Next, the superficial layer of deep cervical fascia is incised along the anterior edge of the SCM, and the sub-SCM layer is dissected to expose the lymphoadipose tissue in lateral neck area. The neck dissection is completed without subplatysmal dissection over the SCM (Figures 1–2).

Sensory evaluation

Tactile skin sensation was evaluated within 1 week of surgery. Based on the course of cutaneous branches of CNs, four anatomical areas were tested: the tip of the ear tab (for greater auricular nerve); submandibular area approximately 2 cm lower than the edge of mandibular bone and 3 cm anterior to the mandibular angle (for transverse CN); lateral neck area approximately 1/3 of the height of neck along the posterior edge of the SCM (for upper branches of supraclavicular nerves); and the sub-clavicular area approximately 3 cm lower than mid-clavicular point (for lower branches of supraclavicular nerves) (Figure 3). The tip of a thin cotton

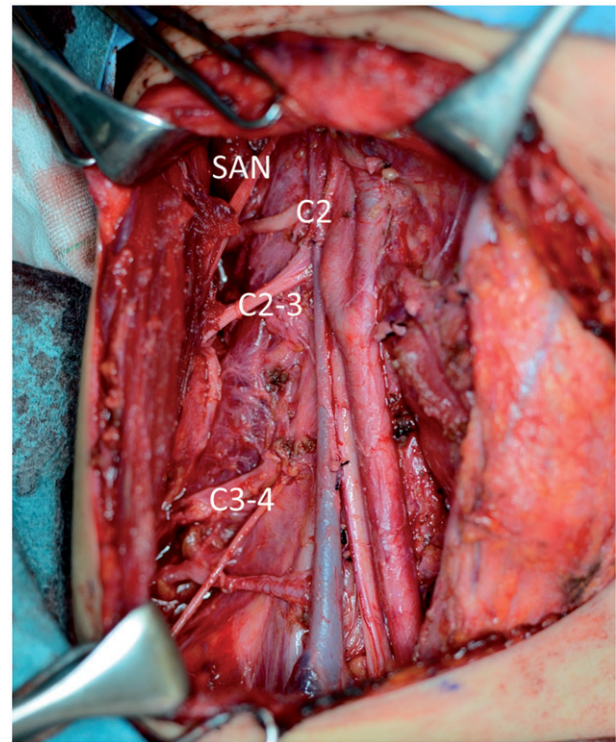


Figure 1. Cervical nerve rootlets have been preserved in the right neck by sub-sternocleidomastoid approach. The trunks of C2–C4 are exposed in the modified radical neck dissection (levels I–V). The skin covering the SCM was kept in place without subplatysmal dissection to preserve the terminals branches of the CNs. SAN: spinal accessory nerve.

swab was placed lightly on the skin and oscillated slowly to check the tactile sensation of the patient. Sensation was recorded as 'preserved' or 'lost'. If sensation was impaired but present, the result was recorded as 'preserved'. Sensory preservation rates were calculated in each tested area. Sensory outcomes were compared between necks with 'CN rootlet-preserved' and 'CN rootlet-resected' to verify the fundamental importance of CN rootlets. Following this, we evaluated whether the 'sub-SCM approach' had more favorable results when compared with the conventional 'subplatysmal approach' in CN rootlet-preserved neck dissections.

Statistical analysis

Pairwise comparisons between groups were performed using the χ^2 test. A p value $< .05$ was considered statistically significant. Statistical calculations were conducted with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient characteristics

This retrospective study included 129 dissected necks from 87 patients with head and neck cancer (male: 57; female: 30). The median age at diagnosis was 66 years

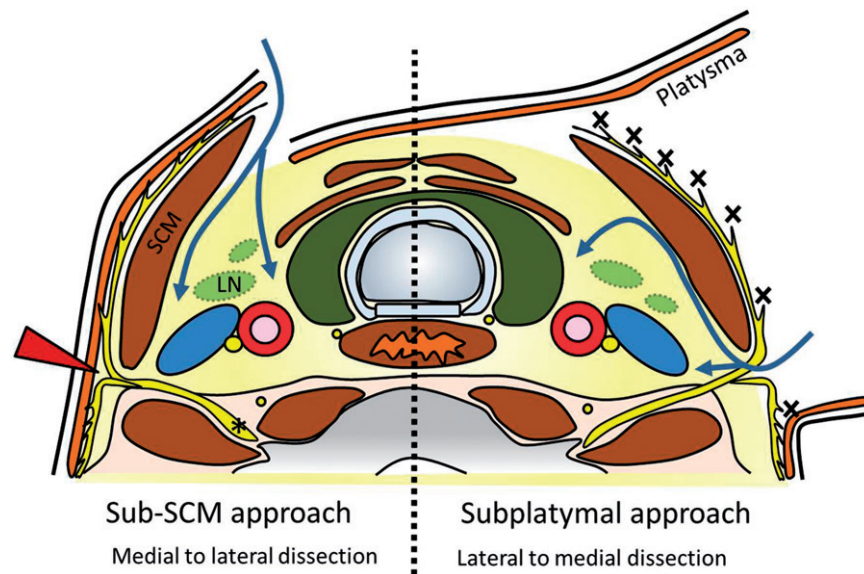


Figure 2. Dissection methods are illustrated. Sub-SCM approach can spare the terminal branches of CN in lateral neck area, while subplatymal approach tends to sacrifice the terminal branches. SCM: sternocleidomastoid muscle; *cervical nerve; Arrowhead: Erb's emissary point of cervical nerves.

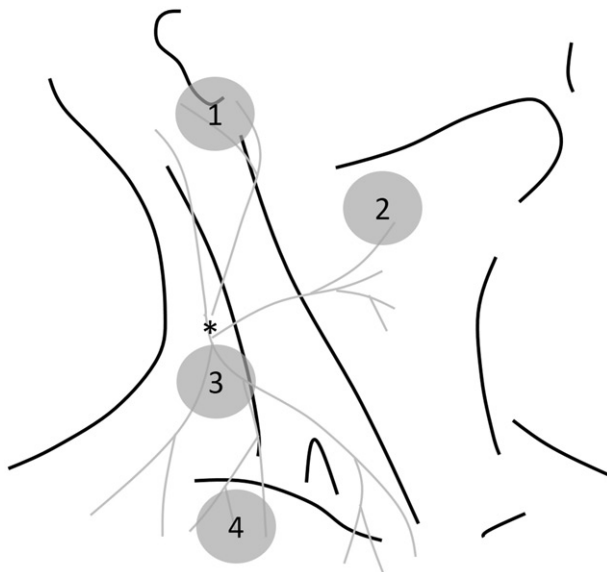


Figure 3. The areas evaluated for cutaneous sensation status. 1. Tip of the ear tab; 2. Submandibular area; 3. Lateral neck area; 4. Sub-clavicular area. *Erb's emissary point of cervical nerves.

Table 1. Characteristics of neck dissection (N = 129).

	CN-r preserved (n = 86)	CN-r resected (n = 43)	p value
Intent of ND			<.001
Therapeutic	28	41	
Elective	58	2	
Range of NDs, sides			<.001
I-V	33	42	
I-IV	9	0	
I-III	29	0	
II-IV	15	1	
Skin incision			<.001
T	25	18	
Oblique along SCM	35	5	
J/inverted J	7	18	
Horizontal	10	1	
Mid-T	9	0	
Mid-I	0	1	
SCM			<.001
Preserved	78	3	
Resected	8	40	
Lateral neck dissection			<.001
Sub-platysmal	32	40	
Sub-SCM	54	3	

CN-r: cervical nerve rootlets; ND: neck dissection; SCM: sternocleidomastoid; p values calculated using χ^2 test.

(range: 31–91). The primary cancer sites were oral (n = 44), oropharynx (n = 13), hypopharynx (n = 12), larynx (n = 7), salivary gland (n = 4), nasopharynx (n = 2), paranasal sinus (n = 2), unknown (n = 2), and cervical esophagus (n = 1). Stages of disease were IV (n = 42), III (n = 18), II (n = 23), I (n = 3), and 0 (n = 1).

Neck dissection range was level I–V (n = 75), I–IV (n = 9), I–III (n = 29), and II–IV (n = 16). Although most of the level I–V dissections were with therapeutic intent, elective MRND had been performed in selected patients with aggressive local disease.

The CN rootlets were preserved and resected in 86 and 43 necks, respectively. More functional, selective approaches were used in the CN rootlet-preserved necks than in the CN rootlet-resected necks (Table 1).

Table 2. Sensory preservation rates after neck dissection by the status of cervical nerve rootlets (N = 129).

	CN-r preserved (n = 86)	CN-r resected (n = 43)	p value
Ear tab	65 (75.6%)	16 (37.2%)	.005
Submandibular	18 (20.9%)	1 (2.3%)	<.001
Lateral neck	64 (74.4%)	1 (2.3%)	<.001
Sub-clavicular	74 (86.0%)	2 (4.7%)	<.001

CN-r: cervical nerve rootlets; p values calculated using χ^2 test.

Sensory outcome

The sensory preservation rate in the ear tab, submandibular, lateral neck, and sub-clavicular area was 75.6%, 20.9%, 74.4% and 86.0%, respectively, in the CN rootlet-preserved necks (n = 86), compared with a sensory preservation rate of 37.2%, 2.3%, 2.3% and 4.7%, respectively, in the CN

Table 3. Sensory preservation rates by dissection approach in necks where cervical nerve rootlets were preserved ($N = 86$).

	Sub-SCM ($n = 54$)	Subplatysmal ($n = 32$)	p value
Ear tab	44 (81.5%)	21 (65.6%)	.098
Submandibular	15 (27.8%)	3 (9.4%)	.043
Lateral neck	50 (92.6%)	14 (43.8%)	<.001
Sub-clavicular	51 (94.4%)	23 (71.9%)	.004

SCM: sternocleidomastoid; p values calculated using χ^2 test.

rootlet-resected necks ($n = 43$). The sensory preservation rates were significantly worse in the CN rootlet-resected necks in all the four tested areas (Table 2).

There was a significant improvement in sensory preservation rates in the submandibular, lateral neck, and sub-clavicular area in CN rootlet-preserved necks following the sub-SCM approach ($n = 54$) when compared with the subplatysmal approach ($n = 32$) (sub-SCM approach: ear tab = 81.5%, submandibular = 27.8%, lateral neck = 92.6%, sub-clavicular = 94.4%; subplatysmal approach: ear tab = 65.6%; submandibular = 9.4%; lateral neck = 43.8%; sub-clavicular = 71.9%; Table 3).

Discussion

Developed by Crile, RND had been the gold standard surgical treatment for cervical metastases of head and neck cancers for decades [13]. The effectiveness of RND is due to its radical resection of various structures adjacent to cervical lymphoadipose tissue as safety margins. The major nerves sacrificed in RND include the SAN and CNs, composed of motor and sensory fibers, respectively. Studies since the 1960s have shown successful results with a less invasive mode of neck dissection that preserves the SAN, SCM, and internal jugular veins [5]. This mode of neck dissection, called MRND, is currently the most common therapeutic neck dissection for conditions with no grossly invasive metastatic nodes. Several reports have shown that preserving the SAN preserves motor function of the shoulder and reduces cervical sensory symptoms, such as tightness and pain [6,14,15]. However, many patients develop cervical symptoms even with preservation of the SAN [7,16]. Subsequently, interest has developed in preservation of the CNs as a predominant factor associated with postoperative sensory function. Studies have shown that preservation of CNs and SAN further reduces the postoperative morbidity and improves patient's quality of life [8,9].

In neck dissection, the CN rootlets deriving from C2 to C4 are exposed. The majority of their branches run medial to lateral and deep to superficial, piercing the cervical lymphoadipose tissue. The cutaneous branches of the CNs radiate from Erb's point, which is located at the posterior edge of the SCM. This study has shown that postoperative anesthesia is almost unavoidable in a wide area of the neck when all the CN rootlets are resected. The skin incision and dissection approach does not significantly change this poor outcome. Therefore, we argue that the preservation of the CN rootlets is a required factor for sensory preservation in neck dissection.

Roh et al. reported cervical sensory outcomes following neck dissection in 53 cases of head and neck cancer, including 23 cases of primary thyroid cancer [9]. A wide area of skin was raised on the subplatysmal layer using a skin incision, such as the McFee, T, and J/inverted J incision. The sensory outcomes after more than one postoperative year were more favorable in the CN rootlet-preserved necks than in the CN rootlet-resected necks. In the CN rootlet-preserved necks, the sensory preservation rate was approximately 70%, 65%, 60% and 70% in the lower part of the auricle, upper anterolateral (submandibular) neck, upper posterior neck, and lower posterior neck, respectively.

Our study reported worse results in the submandibular area when compared with the results obtained by Roh et al. This may be due to the early postoperative sensory evaluation in our study that excluded the effect of neural regrowth. In addition, level I was dissected in the majority (71/86) of necks in our study; therefore, subplatysmal dissection in the submandibular region was necessary.

Dilber et al. reported the sensory outcomes of neck dissection that preserved the CN rootlets in 17 cases of laryngeal cancer. A U-shaped skin incision was used for bilateral neck dissections. The CN rootlets were resected in the diseased side and preserved in non-diseased side. Postoperative cervical sensory function was scored from 0 to 32 points. Changes in sensory function over time, from early postoperative period to six postoperative months were studied prospectively. Sensory loss (0–22 points) was detected in 70.6% and 82.4% of CN-preserved and CN-resected necks, respectively, at 2 weeks postoperatively, and in 41.2% and 100%, respectively, at 6 months postoperatively [8].

These reports demonstrate that cutaneous anesthesia is common in the early postoperative period even when the CN rootlets have been preserved. This indicates that impaired sensory perception following CN rootlet preservation is caused by damage to the terminal branches of the CNs by skin incision or subplatysmal dissection [8]. A slow recovery due to neural regrowth can be expected in the long term; however, this is not functionally ideal [9].

The status of the terminal branches of the CNs is the determinant factor for postoperative sensation when rootlets are preserved. Therefore, the area of postoperative anesthesia is usually in accordance with the area of subplatysmal dissection. Importantly, when the SCM is not resected, subplatysmal dissection over the SCM is not required for completion of neck dissection. It has been reported that sensation over the lateral neck region can be preserved in upper neck dissection using a horizontal skin incision combined with limited subplatysmal dissection over the SCM [12]. However, this combination cannot adequately expose levels IV–V in the lower neck and so its use in comprehensive neck dissection is limited.

In conventional neck dissection, a J/inverted J or laterally placed T incision is used in combination with subplatysmal dissection for surgical exposure of the whole neck area. The removal of lymphoadipose tissue is generally performed in a lateral to medial fashion, starting from the anterior edge of the trapezius muscle and finishing along the carotid sheath medially [17,18]. Although well established, this lateral to

medial subplatysmal approach is not suitable for functional preservation of the CNs. The laterally placed skin incisions and subplatysmal dissection commonly injure the terminal branches of CNs. Furthermore, it is technically difficult to identify and preserve all branches of the CN rootlets in their thin peripheral portions. This difficulty can adversely affect the integrity of en bloc resection [9].

By using the sub-SCM approach, the lymphoadipose tissue in lateral neck is manipulated by sub-SCM dissection instead of subplatysmal dissection. The removal of lymphoadipose tissue begins from the upper medial part along the carotid artery. The CNs are identified at their thick rootlets behind the internal jugular vein and traced laterally toward their peripherals. After preserving all the grossly visible CN branches, dissection is completed at the jugular vein angle. This approach is technically easy and reproducible. In addition, this approach has an oncologic advantage: lymph nodes superficial to the carotid sheath are dissected before exposing the CN rootlets; therefore, the feasibility of CN preservation can be evaluated intraoperatively based on the surgical and/or pathological findings. Any sign that extracapsular extension is present would lead to the abandonment of CN preservation and a more extensive approach can be chosen. Importantly, the decision making on how to treat CNs should be always based on the stage and biology of the disease, with full respect for oncologic safety. A variety of skin incisions can be used in the sub-SCM approach. Most superficial branches of the CNs emerge and radiate from Erb's emissary point at the posterior border of the SCM; therefore, placing a skin incision as distal as possible to Erb's point is favorable to avoid dividing the peripheral branches of the CNs. The author's preference is an oblique skin incision along the anterior edge of the SCM.

This study has shown that the sub-SCM approach results in significantly better sensory outcomes than the conventional subplatysmal approach when the CNs are preserved. However, there are some limitations to this approach. Sensory loss in the submandibular area is common. This is likely to result from unavoidable resection of the branches of transverse CN by skin incision or flap dissection in submandibular area. Additional modifications to this approach should be investigated prospectively to further improve the sensory outcome preferably with both preoperative and postoperative objective data on sensory function. Innovative methods, such as a minimal incision endoscopy-guided or carefully planned robotic approach, may be the next breakthrough [19].

In conclusion, this retrospective study has shown that resection of the CN rootlets in neck dissection is detrimental to postoperative cutaneous sensation. In addition, we have verified that preservation of the CN rootlets and their terminal branches is required to prevent early postoperative sensory loss. The sub-SCM approach, combined with a medially placed skin incision, is suitable for a neck dissection that preserves CN function. This study showed that

there is further scope for functional improvements in the outcomes of neck dissection.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

- [1] Shah JP, Medina JE, Shaha AR, et al. Cervical lymph node metastasis. *Curr Probl Surg*. 1993;30:1–335.
- [2] Shah JP. Cervical lymph node metastases—diagnostic, therapeutic, and prognostic implications. *Oncology*. 1990;4:61–69.
- [3] Martin H, Del Valle B, Ehrlich H, et al. Neck dissection. *Cancer*. 1951;4:441–499.
- [4] Agha-Mir-Salim P, Schulte-Mattler W, Funk U, et al. Origin of shoulder pain after “neck dissection”. Importance of the cervical plexus. *HNO*. 2002;50:544–552.
- [5] Bocca E, Pignataro O, Oldini C, et al. Functional neck dissection: an evaluation and review of 843 cases. *Laryngoscope*. 1984;94:942–945.
- [6] Short SO, Kaplan JN, Laramore GE, et al. Shoulder pain and function after neck dissection with or without preservation of the spinal accessory nerve. *Am J Surg*. 1984;148:478–482.
- [7] van Wilgen CP, Dijkstra PU, van der Laan BF, et al. Morbidity of the neck after head and neck cancer therapy. *Head Neck*. 2004;26:785–791.
- [8] Dilber M, Kasapoglu F, Erisen L, et al. The relationship between shoulder pain and damage to the cervical plexus following neck dissection. *Eur Arch Otorhinolaryngol*. 2007;264:1333–1338.
- [9] Roh JL, Yoon YH, Kim SY, et al. Cervical sensory preservation during neck dissection. *Oral Oncol*. 2007;43:491–498.
- [10] Honda K, Asato R, Tsuji J, et al. Oncologic safety of cervical nerve preservation in neck dissection for head and neck cancer. *Head Neck*. 2017;39:1751–1755.
- [11] Hemmat SM, Wang SJ, Ryan WR. Neck dissection technique commonality and variance: a survey on neck dissection technique preferences among head and neck oncologic surgeons in the American head and neck society. *Int Arch Otorhinolaryngol*. 2017;21:8–16.
- [12] Saffold SH, Wax MK, Nguyen A, et al. Sensory changes associated with selective neck dissection. *Arch Otolaryngol Head Neck Surg*. 2000;126:425–428.
- [13] Crile G. Excision of cancer of the head and neck. With special reference to the plan of dissection based on one hundred and thirty-two operations. *JAMA*. 1906;47:1780–1786.
- [14] Leipzig B, Suen JY, English JL, et al. Functional evaluation of the spinal accessory nerve after neck dissection. *Am J Surg*. 1983;146:526–530.
- [15] Terrell JE, Welsh DE, Bradford CR, et al. Pain, quality of life, and spinal accessory nerve status after neck dissection. *Laryngoscope*. 2000;110:620–626.
- [16] Sist T, Miner M, Lema M. Characteristics of post-radical neck pain syndrome: a report of 25 cases. *J Pain Symptom Manage*. 1999;18:95–102.
- [17] Gavilán J, Herranz J, Martín L. Functional neck dissection: the Latin approach. *Operat Tech Otolaryngol*. 2004;15:168–175.
- [18] Khafif A. Lateral neck dissection. *Operat Tech Otolaryngol*. 2004;15:160–167.
- [19] Choi JY, Kang KH. Robotic modified radical neck dissection with bilateral axillo-breast approach. *Gland Surg*. 2017;6:243–249.