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Main Article

Spinal accessory nerve function after neck dissections

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Abstract
The aim of this study was to evaluate spinal accessory nerve function after functional neck dissection (FND) and radical neck dissection (RND) by monitoring the nerve with electromyographic (EMG) examinations. A prospective, double-blind, clinical study was undertaken in 21 patients (42 neck side dissections) operated on for head and neck malignant diseases, separated into two groups: 10 neck sides in the RND group and 32 neck sides in the FND group. Electromyographic examinations were performed pre-operatively and post-operatively in the third week and third and ninth months. Additionally, a questionnaire, modified from the neck dissection impairment index, was applied to all the patients in order to assess shoulder function in the ninth post-operative month.

All patients had maximum EMG scores pre-operatively. Following the operation, motor amplitudes decreased in both groups. At the third post-operative month, amplitudes decreased to their lowest values. As expected, the decreases in amplitude and EMG score were more prominent in the RND group. Following reinnervation, the amplitudes of the trapezius motor response increased in the FND group but never reached pre-operative values (during the time of follow up). The FND group scores for pain, neck and shoulder stiffness, and disability in heavy object lifting, light object lifting and reaching overhead were significantly lower than those of the RND group.

In FND, one aims to preserve anatomically the spinal accessory nerve, and it is presumed to be intact after the procedure. However, using EMG nerve function monitoring, our study revealed that profound spinal nerve injury was detected immediately after FND surgery, which tended to improve over subsequent months but had not regained its original function by the end of the ninth post-operative month.

Key words: Neck Dissection; Accessory Nerve; Electromyography

Introduction

In head and neck cancer, spread of disease to regional lymph nodes is one of the most important prognostic factors.[1–4] Fifty years after Crile's description of radical neck dissection (RDN), shoulder dysfunction was still accepted as a minor side effect.[5] In 1952, Maurice Ewing and Hayes Martin characterized RDN post-operative disability as 'variable and seldom incapacitating'.[6] In 1961, Nahum *et al.* defined a shoulder syndrome occurring after RDN, comprising a shoulder droop, winged scapula, inability to shrug, and a dull, non-localizing pain, which was present in all patients and was exacerbated by movement, particularly on abduction.[7] According to their findings, active abduction of the shoulder was limited but the full passive range of motion was preserved in most patients. Various modifications of RDN have been developed over the years in order to produce better functional and cosmetic results. Saurez originally described functional neck dissection (FND) in 1963; however, Bocca popularized this technique in Europe. As a result of his anatomical studies, Bocca proposed that the lymphatic system of the neck is enclosed within an aponeurotic envelope and that, by stripping this envelope from the underlying structures, the lymph nodes and channels could be extirpated without sacrificing important neck structures, such as the sternocleidomastoid muscle, internal jugular vein and spinal accessory nerve (SAN).[8]

In this prospective, double-blind, clinical study, we attempted to use objective techniques to measure shoulder function and its impairment in patients undergoing RND and FND procedures. Patients were compared on the bases of pre-operative and post-operative electromyographic (EMG) assessments and post-operative assessment of shoulder dysfunction by a modified neck dissection impairment index (NDII) questionnaire.[9]

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Material and methods

Patients

This double-blind, prospective study was undertaken at the department of otorhinolaryngology in collaboration with the department of neurology, from January 2002 to June 2004. The study group consisted of 21 patients (42 neck side dissections), with 20 men and one woman (aged from 47 to 75 years; mean age 60.47 years). American Joint Committee on Cancer clinical criteria were applied for clinical staging (Table I).

The criteria for including patients in the study were: a malignant tumour of the larynx, floor of mouth or tongue; and a need for a unilateral or bilateral neck dissection, either a classical RND or a FND. None of the patients had undergone previous medical or surgical treatment (Table II). Groups were classified according to the type of neck dissection undergone: 10 RND in group one and 32 FND in group two. All patients underwent bilateral neck dissections: 12 bilateral FND, one bilateral RND, and eight FND and simultaneous RND of the contralateral side. All neck dissections were performed simultaneously with the resection of the primary tumour, except for one patient who underwent a bilateral RND with a three-week time interval between each dissection (Table III). The classical FND technique of Bocca was used in all patients, and all operations were performed by three of the authors (KSO, TD and EAY). Informed consent was obtained from all patients.

Assessment of shoulder dysfunction

A questionnaire modified from the NDII was used in order to assess shoulder dysfunction during the ninth post-operative month.[9] All patients were asked about pain, neck and shoulder stiffness, and disability in lifting heavy and light objects and in reaching overhead, for each neck side separately, and their answers scored as zero (none), one (mild), two (slightly moderate), three (moderate) and four (severe). Results were compared using the Mann–Whitney U test.

Electrophysiologic examination and interpretation of data

Electrophysiologic assessment of the patients was performed by an experienced electrophysiologist blinded to each patient's type of operation. All patients underwent four electrodiagnostic evaluations. The first examination was performed pre-operatively and the second, third and fourth performed post-operatively during the third week and third and ninth month, respectively. All the electrophysiologic studies were performed using either four channel (Dantec Dynamics Key Point version 3.2, Skovlunde, Denmark) or five channel (Medelec-Synergy, Oxford Medical Instruments, Old Woking, UK) electromyography devices. During the investigation, skin temperature was kept above 35°C. Each examination included bilateral studies of the sensory and motor conduction of the median and ulnar nerves, the motor conduction of the accessory nerves, and needle electromyography of the upper extremity and trapezius muscles. Nerve conduction studies of upper extremity nerves were performed according to standard techniques. Motor conduction studies of the accessory nerve were performed by stimulating the nerve with surface electrodes while recording the compound muscle action potential from the ipsilateral trapezius muscle.[10] Disposable concentric needle electrodes (37 mm) were used bilaterally for electromyographic evaluation of upper extremity and trapezius muscles.

Motor and sensory conduction studies of upper extremities were checked in order to exclude any kind of neuropathy which might coincidentally be involving these particular nerves. By evaluating the upper extremity muscles with needle electromyography, it became possible to diagnose cervical radiculopathy syndromes which might be coinciding with the SAN neuropathy.

The motor response of the SAN and the needle EMG findings for the trapezius muscle were assessed in order to clarify the presence of SAN neuropathy. Patients were divided into five different groups

TABLE II

TUMOUR LOCATION

Site	n*	%
Larynx	17	81
Tongue	2	9.5
Floor of mouth	2	9.5
Total	21	100

*Patients

TABLE I

CLINICAL STAGING OF PATIENTS ACCORDING TO TUMOUR–NODE–METASTASIS (TNM) CLASSIFICATION

	N_0	N_1	N_{2a}	N_{2b}	N_{2c}	N_3	Total n*
T_1	0	0	0	0	0	0	0
T_2	3	0	1	1	1	1	7
T_3	4	0	0	2	4	2	12
T_4	0	0	0	0	1	1	2
Total	7	0	1	3	6	4	21

*Patients

TABLE III

OPERATIONS FOR PRIMARY LESIONS

Operation	n*
Total laryngectomy	14
Supraglottic laryngectomy	2
3/4 Horizontovertical laryngectomy	1
Hemiglossectomy	2
Composite resection	1
Resection of floor of mouth	1
Total	21

*Patients

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TABLE IV

SCORING OF DENERVATION AT WEEK 3

Nerve status	Score
Normal	5
Mild partial denervation	4
Moderate partial denervation	3
Severe partial denervation	2
Complete denervation	1

(Table IV) according to the severity of the SAN nerve lesion (normal, mild partial denervation, moderate partial denervation, severe partial denervation and complete denervation). The severity of the SAN involvement was indicated by the amplitude of the SAN motor response, the presence of denervation activity in the trapezius muscle, and the configuration and recruitment pattern of the motor unit potentials, as well as the interference pattern. Because the patients were followed electrophysiologically for nine months, it was also possible to detect reinnervation (Table V). At the third and ninth post-operative months, electrophysiologic data from the patients showed the severity of the SAN lesion as well as the extent of reinnervation (none, mild, moderate and sufficient). Results were interpreted using the Wilcoxon signed rank test and the Kruskal–Wallis test.

Results

Patients

The study commenced with 21 patients (42 neck sides). One patient died of coronary artery disease in the second post-operative month and one patient was lost to follow up in the third post-operative month; hence, they could not undergo the second and third post-operative EMG examinations and the shoulder dysfunction questionnaire.

Thirteen patients received post-operative external beam radiotherapy.

Assessment of shoulder dysfunction

The FND group's questionnaire scores for pain, neck and shoulder stiffness, and disability in lifting heavy objects, light objects and in reaching overhead were significantly lower than those of the RND group (Figure 1).

TABLE V

SCORING OF DENERVATION MATCHING REINNERVATION AT MONTHS 3 AND 9

Nerve status	Score	Reinnervation
Normal	5	
Mild partial denervation	4	Sufficient reinnervation
Moderate partial denervation	3	Moderate reinnervation
Severe partial denervation	2	Mild reinnervation
Complete denervation	1	No reinnervation

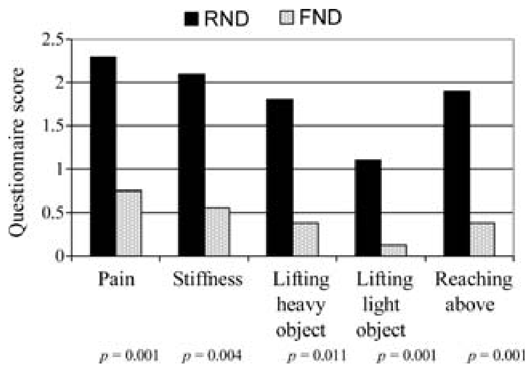

FIG. 1

Assessment of shoulder dysfunction by questionnaire score; *p* values calculated by Mann–Whitney U test. RND = radical neck dissection; FND = functional neck dissection

Electrophysiologic examination and interpretation of data

The motor amplitudes of the trapezius muscle are presented in Figure 2. Pre-operatively, the motor amplitudes of the trapezius muscle were 10.9 ± 2.6 mV and 8.5 ± 3.3 mV in the RND and FND groups, respectively. At the third post-operative week, these amplitudes decreased to 0.7 ± 1.2 mV in the RND group and 3.3 ± 3.1 mV in the FND group. At the third post-operative month, these amplitudes were 0.3 ± 0.6 mV in the RND group and 2.8 ± 3.2 mV in the FND group. At the ninth post-operative month, these amplitudes were 1.3 ± 2.2 mV in the RND group and 4.7 ± 3.3 mV in the FND group. All patients had maximum EMG scores pre-operatively. The patients' post-operative EMG scores are presented in Table VI. Both groups had low post-operative EMG scores, compared with pre-operative values, and this was statistically significant ($p = 0.001$ for FND, $p = 0.006$ for RND). However, in the RND group, the difference between the pre-operative and post-operative EMG scores was greater than that in the FND group. This was also statistically significant. The difference between the groups was prominent during the follow-up period. In the RND group, the

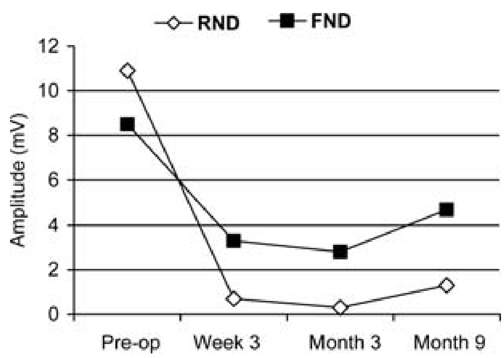

FIG. 2

Motor amplitudes of the trapezius muscle. RND = radical neck dissection; FND = functional neck dissection; Pre-op = pre-operative

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TABLE VI
ELECTROMYOGRAPHY (EMG) SCORES

EMG timing	EMG score (mV ± SD)		p^*
	FND†	RND‡	
Pre-operative	5.0 ± 0.0	5.0 ± 0.0	1.00 (NS)
Week 3 post-op	2.6 ± 1.2	1.4 ± 0.7	0.013
Month 3 post-op	2.8 ± 1.4	1.3 ± 0.7	0.005
Month 9 post-op	3.3 ± 1.1	1.4 ± 1.0	0.001

*FND *vs* RND, Mann–Whitney U test; †$n = 32$ neck sides; ‡$n = 10$ neck sides. SD = standard deviation; FND = functional neck dissection; RND = radical neck dissection; NS = not significant; post-op = post-operative

EMG scores were low post-operatively and no significant reinnervation was observed (Figure 3). On the other hand, the FND group showed reinnervation three to nine months after operation. The difference in reinnervation between the groups was also statistically significant (p = not significant for third week to third month; $p = 0.003$ for third month to ninth month; $p = 0.003$ for third week to ninth month). Although the FND group showed significant reinnervation, no patient showed pre-operative values at the final electrophysiologic evaluation (ninth post-operative month). In both groups, pain and shoulder dysfunction scores were compatible with EMG scores in the ninth post-operative month.

Discussion

Several studies have shown the superiority of SAN-preserving operations compared with SAN-sacrificing operations, in terms of shoulder function and quality of life.[4,11–21] Due to the improvement of nerve function seen in sequential post-operative EMG evaluations in the FND group, pain and shoulder dysfunction scores were found to be better in this group than in the RND group. However, shoulder dysfunction still remained, despite reinnervation of the SAN, and the nerve function never returned to its pre-operative status (as assessed at the ninth post-operative month).

All patients had maximum EMG scores pre-operatively. The amplitudes of the motor response of the trapezius muscle were also normal at initial examination. Following the operation, motor amplitudes decreased in both groups. At the third post-operative month, amplitudes decreased to their lowest values. As expected, the decrease in amplitude and EMG scores was more prominent in the RND group. Following reinnervation, the amplitudes of the trapezius motor response increased in the FND group but never returned to pre-operative values (during the time of follow up).

Functional neck dissection differs from RND in the preservation of the SAN. Although the aim of the former is to preserve the SAN, the nerve may still be injured during the procedure. This injury may occur during retraction of the nerve and the sternocleidomastoid muscle, when the surgeon attempts to dissect the upper jugular and cervical spinal lymph nodes located in the vicinity of the SAN. Spinal accessory nerve dysfunction can be demonstrated by using clinical and electrophysiological tools. Sobol *et al.* tested SAN function indirectly by performing needle EMG of the trapezius muscle in patients with neck dissection, using the trapezius muscle of the unaffected side as a control.[20] All of the 25 patients included underwent an EMG evaluation between the 11th and 39th post-operative week (mean 16.5 weeks), and 11 of them underwent a second EMG one year after the operation. The authors classified the EMG findings from normal to severely abnormal. They found moderately severe SAN damage in a significant percentage of patients undergoing MRND at the first post-operative EMG. However, these patients tended to improve with time.

Our findings were compatible with these observations. Because we checked patients' pre-operative status by EMG and SAN conduction studies, we demonstrated nerve dysfunction more clearly, especially in the FND group. On the other hand, we also documented the improvement of nerve function in these patients, using sequential EMG evaluations.

In another study, Cheng *et al.* compared shoulder dysfunction after three different types of neck dissection (selective, modified radical and radical).[11] They performed SAN conduction studies and trapezius muscle EMG examinations five weeks after the operation. As expected, RND patients had the worst scores on electrophysiologic examination. From the results of post-operative EMGs, SAN conduction studies and isokinetic evaluation, Cheng *et al.* concluded that selective neck dissection patients sustained the least SAN damage. Our findings of mild to moderate damage to the SAN in FND patients were in accordance with these conclusions.

Functional neck dissection aims to preserve the SAN anatomy, and the nerve has been presumed to function well after the procedure. However, using EMG monitoring, we detected a profound SAN injury immediately after FND, which tended to improve over months but which did not return to its original condition at the end of the ninth post-operative month.

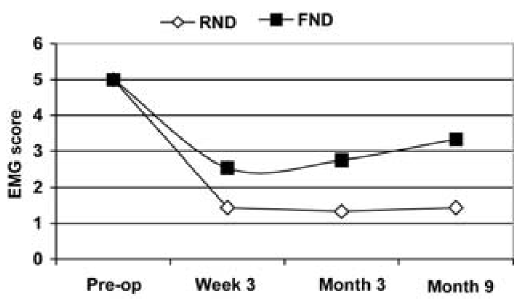

FIG. 3

Electromyography (EMG) scores. RND = radical neck dissection; FND = functional neck dissection; Pre-op = pre-operative

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- **The aim of this study was to evaluate spinal accessory nerve function after functional neck dissection (FND) and radical neck dissection (RND), by monitoring the nerve with electromyographic (EMG) examinations**
- **A prospective, double-blind, clinical study was undertaken in 21 patients (42 neck side dissections) operated on for head and neck malignant diseases, divided into two groups in which 10 neck sides underwent RND and 32 neck sides underwent FND**
- **In the FND group, scores for pain, stiffness of neck and shoulder, and disability in lifting heavy objects, light objects and in reaching overhead were significantly lower than those in the RND group**
- **The aim of FND is to preserve the spinal accessory nerve anatomically and it is presumed to be intact after the procedure. However, by monitoring nerve function with EMG examination, this study reveals significant nerve injury immediately following surgery, which tended to improve but did not return to the pre-operative condition by the end of the ninth month**

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