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TÜBİTAK

Original Article

Clinical and electrophysiological evaluation of shoulder functions in spinal accessory nerve-preserving neck dissection

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Aim: The aim of this study was to evaluate shoulder functions after neck dissection with preservation of the spinal accessory nerve by objective physical examination, electromyographic findings, and subjective patient complaints, and also to investigate the effect of the type of neck dissection.

Materials and methods: The present study included 29 patients on whom unilateral selective or modified radical neck dissection was performed for head and neck cancer and/or metastasis to the neck. Electromyographical findings, range of motion, and pain scores of the shoulder joint were determined for the operated and nonoperated (control) sides.

Results: An electromyographic examination of the trapezius and sternocleidomastoid muscle with superficial and pin electrodes showed a statistically significant difference when comparing the latency and amplitude values of the operated and nonoperated sides ($P < 0.05$). Flexion, abduction, and external rotation of the shoulder joint were found to be significantly affected on the operated side ($P < 0.05$). Electrophysiological differences were not found with regards to neck dissection types. Mild or moderate pain was observed at the early stage with a visual pain scale.

Conclusion: Despite spinal accessory nerve preservation during neck dissection, electrophysiological changes and alterations in clinical functions might be seen in all areas of the nerve that innerves the shoulder muscles.

Key words: Selective neck dissection, shoulder dysfunction, spinal accessory nerve, head and neck cancer, range of motion, rehabilitation

Introduction

Spread of disease to the regional lymph nodes is an important prognostic factor in head and neck cancers. Neck dissection, either elective or therapeutic, is part of the surgical treatment for many patients with head and neck cancer. The gold standard for the control of regional disease is neck dissection (1). While radical neck dissection (RND) had an important role in the treatment of cervical neck metastasis for many years, the oncological requisite for RND became debatable upon the definition of "shoulder syndrome" in the midst of the last century (2). Later on, modified radical neck dissection (mRND) with preservation of the spinal accessory nerve (SAN), internal jugular vein (IJV), and sternocleidomastoid muscle (SCM) and removal of lymphatic tissues with similar oncological results was described. The concept of selective neck dissection (SND) (removal of only the nodal groups at highest risk of metastases with preservation of the nonlymphatic structures) decreased the number of patients with shoulder disability. Thus, the aim was to provide a higher quality of life by avoiding the shoulder syndrome, which occurs upon the sacrifice of the SAN and is characterized by sagging shoulder, limited motion, and pain.

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Although it is generally agreed that the preservation of the SAN has no negative impact on survival, whether its preservation always provides complete functionality or whether its sacrifice always leads to features of conventional shoulder syndrome has been widely argued.

In most of the studies of shoulder syndrome, objective assessment was performed by electromyography (EMG). Gordon et al. (3) showed that several innervation problems might occur even with the preservation of the SAN. Remmler et al. (4) employed a clinical examination and EMG for the assessment process, and based on the EMG findings, classified as solely denervation and innervation, they determined that a transient functional loss occurred with mRND at the early stage in most cases. They highlighted that development of shoulder syndrome following neck dissection was a multifactorial problem in these studies. The degree of injury to the SAN during the operation, individual differences in the innervation of the trapezius muscle, and variations in the course of the SAN through the neck are thought to account for the development of shoulder syndrome.

This study aimed to evaluate SAN functions after neck dissection with preservation of the SAN by objective clinical physical examination, EMG or electroneurography (ENG) findings, and subjective patient complaints, as well as to investigate the effects of neck dissection type.

Materials and methods

Included were 29 patients who underwent unilateral SND and mRND due to head and neck cancer and/or neck metastasis. Patients who received radiotherapy before or after neck dissection and patients with neurological or orthopedic diseases of the neck and shoulder were excluded. The other nonoperated side was considered as the control group. The patients were informed of the study in detail and their consents were taken. After an ear-nose-throat and head and neck examination, they were evaluated at the Department of Neurology and Department of Physical Therapy and Rehabilitation (PTR) by the same physicians. Patients in the first postoperative 12-week period were excluded from the study.

Records of the 29 patients enrolled in the study were reviewed to determine the primary tumor localization, histopathological diagnosis, clinical staging, date of surgery, type of surgery, and any pre- or postoperative adjuvant therapy performed.

Each patient was tested in the neurology department by the same physician using a Dantec Keypoint EMG-ENG device (Natus Medical Incorporated, San Carlos, CA, USA). Surface and pin electrodes were used for recording. A nerve conduction study (ENG) using surface electrodes was planned, with referral to the applications of Green et al. (5). Active electrodes were placed on the upper part of trapezius muscle, whereas the reference electrode was positioned over the muscle tendon. Electrical stimulus was applied superficially between the clavicle and the mastoid protuberance, and behind the SCM muscle when preserved. Stimulus intensity and duration were increased until the maximal amplitude level was achieved. Latency was defined as the time from the application of stimulus to the initial negative deflection of the amplitude. Amplitude was measured from peak to peak in millivolts. The distance between the recording and stimulating electrodes was measured. This was considered to be the same for the other side of the neck. Recording electrodes were placed on all 3 parts of the trapezius (lower/middle/upper). In the pin EMG of the trapezius, the recording pin electrodes were inserted into the trapezius muscle, where the midclavicular line crossed the upper part of the muscle. For SCM muscle testing, recording pin electrodes were inserted in the middle third of the muscle. Recordings were made at rest and during mild or maximum contractions.

Latency values and amplitude values obtained from the neck dissection side and from the nonoperated control side were compared and statistical analysis was done using the Wilcoxon test.

The time interval between the patient's surgery date and EMG-ENG application was calculated. Two patient groups were formed, encompassing patients who were within the first 12 months after surgery and those who were 12 months beyond surgery. The differences were analyzed statistically.

The patients' shoulder examination was performed by a physician from the PTR department.

The findings from the operated side and nonoperated side (control group) were recorded. During the shoulder examination, the presence of asymmetry, sagging shoulder, and winging of the scapula were determined through inspection. The EMG-ENG findings of patients with and without winged scapula were compared statistically.

While the patient was in sitting position, the 2 shoulders were examined during both active and passive flexion, extension, abduction, adduction, internal rotation, and external rotation, and the degrees were measured with a goniometer. Range of motion (ROM) of the shoulder joints on the neck dissection side and on the nonoperated control side were statistically analyzed.

Pain complaints of the patients were assessed with a visual pain scale [visual analog scale (VAS)] (6). During VAS assessment, the degree of pain was marked on a horizontal line at an interval from 0 to 100 (0: no pain, 100: severe pain). The corresponding number of the marked point on the ruler was then considered as the expression of pain in percentages. SPSS 12.0 was used for data analysis. The Mann-Whitney U test was used for comparison of the groups, the Wilcoxon test was used for comparison of the operated and nonoperated sides, and the Kolmogorov-Smirnov test was used when comparing VAS results according to the duration.

Results

Of the 29 patients included in the study, 7 were women (24.1%) and 22 were men (75.8%). The patients were between 38 and 80 years of age, with the mean age being 57.6 years. The SAN was preserved in all of the cases. Neck dissection was performed concomitantly with the treatment of the primary tumor. Table 1 shows the type of the neck dissection and distribution of staging. The classification of neck dissection was done according to the classification that was revised in 2008 (7).

Table 2 shows the comparisons of the latency values found during the objective assessment with EMG-ENG on the operated side and on the other side considered as the control. Of note is the observed statistically significant asymmetry in the comparison of the operated side and the control side in the latency and amplitude measurements with

Table 1. Distribution of neck dissections according to the clinical staging of the neck.

Neck dissection	N0	N1	N2a	N2b	N2c	N3	Total
SND (II-IV)	11	1	-	-	-	-	12
SND (I-IV)	6	1	-	-	-	-	7
mRND (I-V)	1	3	5	-	-	-	9
SND (I-III)	1	-	-	-	-	-	1

Table 2. Comparison of latency values (ms) of the operated side and the control side.

Accessory nerve	Operated	Control	P	n
Lower trap. (mean ± SD)	8.64 ± 2.07	5.24 ± 0.9	<0.001	19
Middle trap.	5.7 ± 2.3	3.41 ± 0.57	<0.001	24
Upper trap.	4.31 ± 1.15	2.56 ± 0.69	<0.001	25
Pin, trap.	5.63 ± 4.30	2.88 ± 0.58	0.03	25
Pin, SCM	5.15 ± 3.12	2.24 ± 1.7	<0.001	28

$P < 0.05$

superficial electrodes on the lower, middle, and upper parts of trapezius muscle and with pin electrodes in the trapezius and SCM muscles ($P < 0.05$).

On the operated side, the type of neck dissection performed and changes in the latency and amplitude values were examined. Table 3 shows the comparisons of the latency values in mRND and other neck dissections (NDs) on the operated side. Other NDs included SND II-IV (44.8%), SND I-IV (24.1%), and SND I-III (3.4%). Statistical analysis of the latency and amplitude values showed no significant difference between mRND and other NDs ($P > 0.05$).

Shoulder joint ROMs were determined (flexion, abduction, internal rotation, and external rotation) in the patients with active and passive movements. Active shoulder joint ROMs were observed to be affected on the operated side relative to the normal side, especially for flexion and abduction (Table 4). The difference in flexion and abduction was highly significant ($P < 0.001$) in the statistical analysis of shoulder joint ROMs on the operated side and the control side. While external rotation was also affected by the operation ($P < 0.05$), change in internal rotation was not statistically significant ($P > 0.05$).

The cases were examined for the presence of winging at the scapula (scapula alata). Of the patients, 8 (27.5%) were found to have scapula alata. The latency values of the patients with scapula alata were compared to those of the patients without scapula alata (Table 5). Statistical analysis showed a significant difference only in the latency values of the upper part of the trapezius ($P < 0.05$).

Each subject was questioned about pain, and subjects were evaluated with the VAS (Table 6). While 24% of the patients had no pain at all, 1 patient suffered from very severe pain. The patient with very severe pain was diagnosed as having reflex sympathetic dystrophy.

Table 3. Comparison of latency values in modified radical neck dissection (mRND) and other NDs on the operated side.

Accessory nerve	mRND	Other NDs	P
Lower trap. (mean ± SD) n	7.88 ± 2.24 7	9.08 ± 1.92 12	0.277
Middle trap.	5.93 ± 3.33 8	5.58 ± 1.64 15	0.591
Upper trap.	4.33 ± 1.41 8	4.3 ± 1.05 17	0.511
Pin, trap.	6.17 ± 3.67 7	5.42 ± 4.6 18	0.657
Pin, SCM	4.95 ± 1.15 8	5.23 ± 3.74 20	0.360

Table 4. Comparison of active shoulder joint motion ranges on the operated and the control sides.

Shoulder function	Operated (mean ± SD)	Control (mean ± SD)	n	P
Flexion	131.9 ± 27.6	153 ± 16.6	29	<0.001
Abduction	130.5 ± 29.8	154.7 ± 15.2	29	<0.001
Int. rotation	72.3 ± 15.1	73.7 ± 14	29	0.588
Ext. rotation	66.9 ± 12.4	69.8 ± 12.6	29	0.024

Table 5. Comparison of electromyography (latency, ms) findings of patients with or without scapula alata on the operated side.

Scapula alata		Lower trap.	Middle trap.	Upper trap.	Pin, trap.	Pin, SCM
+	Mean ± SD	8.06 ± 2.05	6.91 ± 3.34	4.93 ± 1.35	6.02 ± 4.03	4.8 ± 1.49
	n	5	7	8		6
-	Mean ± SD	8.85 ± 2.11	5.17 ± 1.51	4.02 ± 0.95	5.54 ± 4.46	5.25 ± 3.53
	n	14	16	17	20	21
	P	0.444	0.154	0.037	0.869	0.755

Table 6. Rating of shoulder pain based on the visual analog scale.

Degree of pain	Number of patients	Percent (%)
No pain	7	24.1
Mild pain	8	27.6
Moderate pain	9	31
Severe pain	4	13.8
Very severe pain	1	3.4
Total	29	100

Pain was graded as shown above, based on the VAS. Patients were grouped according to the postoperative assessment time, as being within 12 months or beyond 12 months. The association of pain with the time duration is shown in the Figure. Of note is the presence of mostly mild and moderate pain in the early stage (initial 12 months), whereas most patients did not suffer from pain in the late stage (the next 12 months). The only patient with very severe pain was in the early stage.

Discussion

Neck dissection is one of the therapeutic alternatives employed in the neck metastasis of head and neck cancers. The primary principle of cancer surgery is to save the patient from the cancer; however, it should also include maintenance of the quality of life, physical functions, and even cosmetic appearance. Shoulder syndrome occurring after SAN-preserving neck dissection might lead to serious functional loss and alteration of cosmetic appearance.

Individual differences have been identified regarding shoulder syndrome. These differences might be related to different innervation sources of the trapezius muscle other than the SAN and functional and electromyographical differences with emphasis on the patient's sensitivity. Krause (8), after 54 conventional RNDs, reported the development of shoulder syndrome in 31%, no problems in 28%, and the presence of minor functional limitation and pain in 41% of the cases. Leipzig et al. (9) objectively assessed the shoulder functions pre- and postoperatively in patients who underwent different types of neck dissection and determined each risk factor that would cause injury to the nerve for each patient. They classified the degree of the SAN injury and concluded that there was an association between shoulder function disorder and dissection type where the SAN was minimally dissected or stretched. The authors reported that the incidence of shoulder dysfunction increased with the increase in the length of the dissected nerve and in the degree of injury. This was attributed to careless dissection and traction of the nerve. The same publication determined minimal

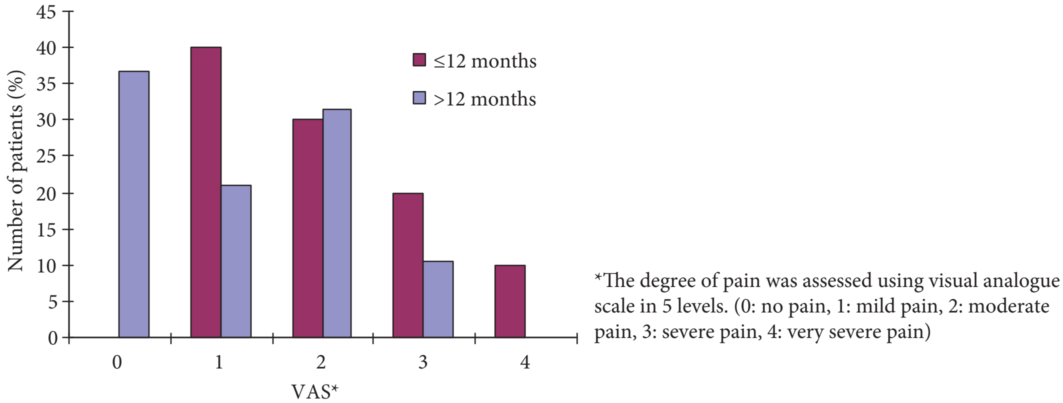

Figure 1. Pain scale values of patients in postoperative 12 months and after 12 months.

pain and dysfunction, despite the SAN being cut in 14 of 35 patients who underwent RND, and the presence of sustained sagging shoulder in 25% of the patients who underwent mRND. Weitz et al. (10) stated that the trapezius muscle had double innervation, where the second innervation was from the motor nerve roots of C 2-3-4. These motor roots were claimed to be positioned on the prevertebral fascia, thus being spared during RND because of their deep-seated location. In an anatomical study by Krause, it was determined that the trapezius muscle was 6.4% innerved by only the cervical plexus, whereas 17.8% of it was innerved by double innervation from both the SAN and the cervical plexus, each being totally independent (8).

Despite preservation of the SAN, reflection of the impact on EMG values was observed to be different for each patient. Prolongation of the latency values on the operated side relative to the healthy side was greatest in the SCM pin EMG. The more frequent impact on the SCM was attributed to opening the muscle sheath and continual manipulation of the muscle during operation. This observation was also made in a study by Zibordi et al. (11). They compared the EMG findings of the SCM and trapezius in patients who underwent conservative neck dissection. The rates of mild to severe peripheral neurogenic lesions were determined for both muscles, and the SCM (48.8%) was affected more frequently than the trapezius (15.9%). In this study, the difference was reported to be related to a small branch of the SAN innerving the SCM muscle, and more importantly to surgical trauma.

The transient functional loss at the early postoperative period was shown to be improved in the late period through muscle strength, joint ROM, and electrophysiological studies. Köybasioglu et al. (12) compared the EMG recordings of mRND and lateral neck dissection (LND) (SND II-IV) in patients, taken preoperatively and at 14-21 days and 3 months postoperatively. They observed denervation potentials in all of the LND subjects (100%) and in 75% of subjects with mRND in the early postoperative period, whereas in the late postoperative period, LND subjects with denervation potentials decreased to 4 patients (25%) and denervation potentials were completely cleared in mRND patients. The loss of motor unit potentials in the early stage was observed to be totally improved with both ND techniques. The transient functional loss of the SAN in the early stage was also observed by Remmler et al. (4). Following neck dissection with preservation of the SAN, significant improvements in trapezius muscle functions were seen 6 months postoperatively, and improvements after 6 months were reported to be minimal. They related the reversible phase of trapezius dysfunction to the retraction of tissues during dissection. The authors stated that compared to the SAN-preserved group, upper and middle trapezius muscle functions were altered significantly in the group in which the nerve was cut, with no improvement during the 12-month observation period. Similarly, Zibordi et al. (11) also stated that the SAN would regain its functions, and improvement in the EMG was seen after 1 year.

We observed that the EMG latency and amplitude values were not different between mRND and other NDs in our study. Cheng et al. (13) examined EMG findings in patients who underwent SND, mRND, and RND, and they compared the latency and amplitude values in mRND and SND where the nerve was preserved. While there was an evident decrease in the amplitudes of patients with mRND compared to patients with SND, no difference was observed in the latencies. The results of the studies that compared these 3 NDs were in agreement with our findings (14,15). Köybasioglu et al. (12) compared the patients on whom they performed mRND or LND, and they found that the results were better in mRND patients. This was related to the continual retraction of the SCM until the end of the operation for a better view of the jugular lymphatics during the LND; on the other hand, in mRND, the SAN is separated from the surrounding tissues from the beginning of the procedure, with less traction in SCM cuts. Cappiello et al. (16) compared 2 different SNDs and found lower dysfunction of the shoulder in SND II-IV than in SND II-V. Sobol et al. (17) evaluated the functional results of 3 neck dissection techniques [RND, mRND, and supraomohyoid ND (SND I-III)] based on EMG results and shoulder movements. Patients who underwent supraomohyoid ND had better results than patients who were operated on with the other 2 methods. This difference was related to the fact that the posterior region, and as a consequence the SAN, was less injured in supraomohyoid ND.

To prevent shoulder dysfunction and other morbidity after neck dissection, a limited number of NDs have been performed in the last decade. Shoulder morbidity is reported to differ depending on whether sublevel IIB is dissected or not. A number of reports have clearly documented the oncologic safety of more limited SNDs, avoiding the need for dissection of sublevel IIB in selected patients (18-20). In a recent prospective study, Celik et al. (21) evaluated the relationship between SAN functions and sublevel IIB-preserving SND in 41 necks of 30 patients with laryngeal cancer who underwent unilateral or bilateral neck dissection. The results showed that none of patients developed shoulder syndrome. The authors concluded that preserving sublevel IIB during SND decreases trauma to the SAN and improves functional results. However, sublevel IIB should be dissected in patients with positive nodal diseases in sublevel IIA and/or extracapsular tumor spread and for primary tumors of the nasopharynx, oropharynx, hypopharynx, oral cavity, and nasal cavity (22).

To determine the functional state of the shoulders of our patients, we measured shoulder-joint ROM postoperatively. The difference between the healthy and operated sides was statistically significant for active flexion, abduction, and external rotation, whereas no difference was observed for internal rotation between the 2 sides. Cheng et al. (13) evaluated the joint ROM using the Cybex isokinetics system in patients who underwent SND, mRND, and RND. They measured ROM for the healthy and operated sides preoperatively and at 1 and 6 months postoperatively, recording flexion-extension, abduction-adduction, and internal rotation-external rotation. In the SND group, a marked decrease in flexion-extension and abduction-adduction was observed at 1 month postoperatively ($P < 0.05$), with reversal to preoperative values at 6 months postoperatively. In mRND patients, flexion-extension, abduction-adduction, and internal rotation-external rotation showed a marked decrease at 1 month postoperatively compared to values prior to surgery ($P < 0.05$), with reversal to preoperative values at 6 months postoperatively, with the exception of flexion-extension. The ROM values of patients who underwent RND were markedly decreased at 1 and 6 months postoperatively compared to values prior to surgery ($P < 0.05$). Similar results were reported by Sobol et al. (17), who measured and compared shoulder ROM values during preoperative and postoperative periods. Although in the procedure in which the SAN was preserved, the ROM values of patients were observed to be better than those of patients with RND, the procedure was shown to cause shoulder insufficiency. However, the ROM was better than in the other 2 groups of patients who underwent supraomohyoid ND. During the patients' 1-year postoperative follow-up, all of the parameters were found to be much more evidently improved in the group with SAN preservation than in those who had RND. Teymoortash et al. (23) conducted a study about different types of SND and no statistically significant difference between the evaluations of pre- and postoperative ROM was found.

EMG, which has been used as the basic examination method in studies in the literature, is nominated as the most objective evaluation method in shoulder syndrome. Sobol et al. (17) found a high correlation between EMG findings and active abduction angles. In our study, we compared the EMG-ENG values of patients with and without scapula alata (winged scapula) detected through inspection. In EMG of the upper trapezius, the latency values were observed to be longer in patients with scapula alata. Statistical analysis showed the occurrence of a significant difference ($P < 0.05$). Zibordi et al. (11) found a satisfactory correlation between trapezius muscle EMG findings and muscle test results, and they stated that the muscle test was a good, sufficient technique in the measurement of SAN functions.

In our study, we observed that patients' pain complaints disappeared at the late period. Despite preservation of the SAN, the presence of very severe pain in 1 patient (3.4%) and severe pain in 4 patients (13.8%) can be explained by individual pain thresholds and differences in perception, as well as by numerous factors causing pain. Persisting shoulder pain following RND was thought to be due to the sacrifice of the SAN. Pain in the neck, shoulder, and other regions, which can be seen after RND, was thought to be due to sensory nerve cuts independent from the SAN, with possible contribution from scar tissue and neuroma (24). In the literature, another factor related to pain is thought to be stretching of the scapula retractor (rhomboid muscle) and elevator (levator scapulae) as a result of an imbalanced pull force of the serratus anterior. Periarthritis of the joint is another pain factor. Less frequently, osteoarthritis of the sternoclavicular joint is proposed to be the cause of the pain (25). Dilber et al. found that injury to the cervical plexus during SND might lead to sensory loss; however, in cases where the plexus is sacrificed, this would not result in pain (26).

In conclusion, despite preservation of the SAN during neck dissection, electrophysiological changes and alterations in clinical functions might be seen in all areas of the nerve that innerve the shoulder muscles. Prevention of shoulder complaints after neck dissection may be achieved with physical therapy programs. Performing an ENG-EMG examination at certain intervals during the postoperative period can provide significant contributions to the early detection of morbidity in shoulder functions and its rehabilitation.

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