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Review article

Selection and delineation of lymph node target volumes in head and neck conformal radiotherapy. Proposal for standardizing terminology and procedure based on the surgical experience

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Abstract

The increasing use of 3D treatment planning in head and neck radiation oncology has created an urgent need for new guidelines for the selection and the delineation of the neck node areas to be included in the clinical target volume. Surgical literature has provided us with valuable information on the extent of pathological nodal involvement in the neck as a function of the primary tumor site. In addition, few clinical series have also reported information on radiological nodal involvement in those areas not commonly included in radical neck dissection. Taking all these data together, guidelines for the selection of the node levels to be irradiated for the major head and neck sites could be proposed. To fill the missing link between these guidelines and the 3D treatment planning, recommendations for the delineation of these node levels (levels I–VI and retropharyngeal) on CT (or MRI) slices have been proposed using the guidelines outlined by the Committee for Head and Neck Surgery and Oncology of the American Academy for Otolarynology-Head and Neck Surgery. These guidelines were adapted to take into account specific radiological landmarks more easily identified on CT or MRI slices than in the operating field.

Keywords: Conformal radiotherapy; Head and neck tumor; Node level; Computed tomography; Magnetic resonance imaging

1. Introduction

The use of more precise ways to deliver the dose to the target volumes and protect the normal tissues at risk (e.g. intensity-modulated radiation therapy, conformal radiotherapy) obviously requires a proper knowledge of the volumes to be irradiated for any particular disease site, and an accurate delineation of these volumes on a three-dimensional (3D) basis. This requirement has always existed, but was greatly over simplified in 2D planning in the sense that one dimension was evidently missing or greatly over simplified. For instance, in head and neck tumors irradiated as still suggested in all major textbooks by two opposed lateral fields, there was no need to define the tumor or lymph nodes extension in the mediolateral direction. In some ways, conformal radiotherapy thus requires that the radiation oncologist approaches this issue with the spirit of a surgeon planning and performing his operation. The surgical field would be replaced by computed tomography (CT) scan (or magnetic resonance imaging (MRI)) images and the scalpel by a mouse or an electronic pencil. Without any doubt, this represents a new challenge for the radiation oncologist community. Such a procedure requires a precise knowledge of CT scan- or MRI-based anatomy, as well as microscopic extension of the tumors and/or nodes in the fatty tissues, along the aponeurotic fascia and muscles, or around the blood vessels and nerves. In this respect, the use of guidelines for the selection of the volumes to be irradiated, as well as standardized rules for delineation of these volumes based of modern imaging modalities should be promoted for every disease sites. Such guidelines and rules would contribute to reducing differences in treatment planning from patient to patient and make comparison of clinical series or conduction of multicenter trials much more accurate.

In this framework, the objective of the present review is to propose guidelines for the selection and definition of target volumes in the neck of patients with head and neck squamous cell carcinomas. Such guidelines are based on standardized neck dissection terminology adopted by head

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and neck surgeons. First, the terminology adopted by head and neck surgeons for the lymph node levels and for node dissection are presented. Then, information on metastatic nodal extension of major tumor sites are reviewed, from which guidelines for target volume extension are proposed. Lastly, following the surgical terminology, tentative rules are proposed for the delineation of the neck node levels based on modern imaging modalities.

2. Classification of neck node levels and dissection terminology

The head and neck region has a rich network of lymphatic vessels draining from the base of skull through the jugular nodes, the spinal accessory nodes and the transverse cervical nodes down to the venous jugulo-subclavian confluent or the thoracic duct on the left side and the lymphatic duct on the right side [44,62]. A comprehensive anatomical description of this network has been performed by Rouvière more than 50 years ago [44]. The whole lymphatic system of the neck is contained in the cellulo-adipose tissue delineated by aponeurosis enveloping the muscles, the vessels and the nerves. Typically, the lymphatic drainage remains ipsilateral, but structures like the soft palate, the tonsil, the base of tongue, the posterior pharyngeal wall and especially the nasopharynx have bilateral drainage. On the other hand, sites such as the true vocal cord, the paranasal sinuses and the middle ear have few or no lymphatic vessels at all.

The nomenclature of head and neck lymph nodes has been burdened by various confusing synonyms still in use in major textbooks or articles. More recently, several expert bodies have proposed the use of systematic classifications aiming at standardizing the terminology. Following the description of Rouvière, the TNM atlas proposed a terminology dividing the head and neck lymph nodes into 12 groups [58]. In parallel to this classification, a Committee for Head and Neck Surgery and Oncology of the American Academy for Otolaryngology – Head and Neck Surgery has been working on a classification (the so-called Robbins' classification) dividing the neck into six levels including eight node groups [41]. This classification is based on a description of a level system which has been adopted for a long time by the Head and Neck Service at the Memorial Sloan-Kettering Cancer Center [46]. As one of the objectives of the Robbins's classification was to develop a standardized system of terminology for neck dissection procedures, only the lymph node groups routinely removed during neck dissection were considered. For example, retropharyngeal and parotid nodes which are not removed during a standard neck dissection are not included in Robbins' classification. The terminology proposed by Robbins was also accepted by representatives of the major European Cancer Centers (Milan, Villejuif, Amsterdam) and was recommended by the UICC [59]. A comparison between the TNM and the Robbins's terminology is shown in Table 1. The major advantage of the Robbins's classification over the TNM terminology is the definition of the boundaries of the node levels. These boundaries are delineated based on anatomical structures easily identifiable by the surgeons during the neck dissection procedures, such as major blood vessels, muscles, nerves, bones and cartilage. The reader is referred to the original manuscript of Robbins for a comprehensive anatomical description of these various levels [41]. Recently, Robbins refined his classification and proposed to further divide level II into levels IIa and IIb, and level V into level Va and Vb [42]. Anatomically, levels IIa and IIb are separated by the spinal accessory nerve, whereas levels Va and Vb are divided by the omohyoid muscle. Clinically, such distinction has some implications. Level IIb, for example, is more likely associated with primary tumors arising in the oropharynx or nasopharynx, and less frequently involved in tumors of the oral cavity, larynx or hypopharynx. Similarly, nodes in level Va are more often associated with primaries of the nasopharynx, oropharynx or the cutaneous structures of the posterior scalp, whereas level Vb is most likely associated with tumors arising in the thyroid gland.

Based on the definition of the neck level, the Committee for Head and Neck Surgery and Oncology of the American Academy for Otolaryngology – Head and Neck Surgery made several recommendations for the neck dissection terminology. The main objectives of such recommendations were to develop a standardized terminology limited to the use of few defined procedures where the lymphatic and non-lymphatic structures removed are unambiguously described. Such recommendations had to correlate with the biology of neck metastases and meet the standards of oncologic principles. The standard procedure is the radical neck dissection where levels I to V are removed with the internal jugular

Table 1
Comparison between the TNM atlas terminology and the Robbins' classification of the lymph nodes of the neck

TNM atlas for lymph nodes of the neck		Robbins' classification	
Group number	Terminology	Level	Terminology
1	Submental nodes	Ia	Submental group
2	Submandibular nodes	Ib	Submandibular group
3	Cranial jugular nodes	II	Upper jugular group
4	Medial jugular nodes	III	Middle jugular group
5	Caudal jugular nodes	IV	Lower jugular group
6	Dorsal cervical nodes along the spinal accessory nerve	V	Posterior triangle group
7	Supraclavicular nodes	V	Posterior triangle group
8	Prelaryngeal and paratracheal nodes	VI	Anterior compartment group
9	Retropharyngeal nodes		
10	Parotid nodes		
11	Buccal nodes		
12	Retroauricular and occipital nodes		

vein, the sternocleidomastoid muscle and the spinal accessory nerve. Every procedure which preserve at least one of the non-lymphatic structures (i.e. the vein, the muscle or the nerve) is called a modified radical neck dissection. A procedure which does not remove all the node levels is called a selective neck dissection. There are four subtypes of selective neck dissection: (a) a supraomohyoid neck dissection (levels I–III), (b) a posterolateral neck dissection (levels II–V), (c) a lateral neck dissection (levels II–IV) and (d) an anterior compartment neck dissection (level VI). When additional lymphatic nodes (e.g. retropharyngeal, upper mediastinal or paratracheal nodes) or non-lymphatic structures (e.g. the parotid gland, the skin, the carotid artery, the hypoglossus nerve) have to be removed, the procedure is called an extended radical neck dissection. Although not recommended by the Committee for Head and Neck Surgery and Oncology of the American Academy for Otolaryngology – Head and Neck Surgery, some authors still use the terminology of 'functional neck dissection' which usually corresponds to a modified radical neck dissection sparing the sternocleidomastoid muscle, the internal jugular vein and the spinal accessory nerve [4,24]. Such terminology should not be used any longer.

3. Metastatic nodal extension of squamous cell carcinomas of the oral cavity, pharynx or larynx

3.1. Distribution of clinically involved lymph nodes in the neck

3.1.1. Cervical lymph nodes

The metastatic spread of head and neck tumors into cervical lymph nodes is rather consistent and follows predictable pathways at least in the neck which has not been violated by previous surgery or radiotherapy. Bataini and Lindberg reviewed the clinical pattern of metastatic neck involvement in patients with head and neck squamous cell carcinomas of the larynx, hypopharynx, oropharynx and oral cavity treated between 1948 and 1978 [3,28]. For nasopharyngeal tumors, data from a more recent study have been pooled with those reported by Lindberg [50]. These data are summarized in Table 2. In their original papers, these authors did not use the Robbins' classification for the neck node levels. Their terminology has been translated into the node levels according to the correspondence presented in Table 1. In Table 2, the frequency of metastatic lymph nodes is expressed as a percentage of the node positive patients. For example, it shows that in patients with oropharyngeal tumors, 64% had clinical lymph node metastasis. Among these patients, 13% had nodes in the ipsilateral level I, 81% in the ipsilateral level II, and so on.

The frequency of neck node metastasis as well as the distribution of the clinically involved nodes depend to a major extent on the primary tumor site. Typically, nasopharyngeal and hypopharyngeal tumors have the highest propensity of nodal involvement which occurs in 80 and 70%, respectively. Cranial and anterior tumors (e.g. oral cavity tumors) mainly drain into levels I, II and III whereas more caudally located tumors (i.e. laryngeal tumors) mainly drain into levels II and III and to a lesser extent into levels IV and V. Contralateral nodes are very rarely invaded except for midline tumors or tumors of those sites where bilateral lymphatic drainage has been reported, e.g. soft palate, base of tongue and pharyngeal wall. Even for those tumors, contralateral involvement occurs at a much lower frequency reaching for example in base of tongue tumors with clinically positive nodes, 31% in the contralateral level II compared with 73% in the ipsilateral level II (data not shown). Interestingly, the node distribution follows the same pattern in the contralateral neck as in the ipsilateral neck. Except for nasopharyngeal tumors, involvement of the ipsilateral level V is a rather rare event occurring in less than 1% of all oral cavity tumors, in less than 10% of all oropharyngeal and laryngeal tumors and in about 15% of all hypopharyngeal tumors. It almost never occurs in the contralateral level V. Nasopharyngeal tumors behave differently than the other head and neck tumors. These highly lymphophylic tumors have almost the same risk of nodal involvement in the ipsilateral and the contralateral neck, and present a preferential involvement of level V occurring in almost one third of patients.

Table 2
Distribution of clinical metastatic neck nodes from head and neck squamous cell carcinomas[a]

Tumor site	Patients with N+ (%)	Distribution of metastatic lymph nodes per level (percentage of the node- positive patients)					
		I	II	III	IV	V	Other[b]
Oral cavity ($n = 787$)	36	42/3.5[c]	79/8	18/3	5/1	1/0	1.4/0.3
Oropharynx ($n = 1479$)	64	13/2	81/24	23/5	9/2.5	13/3	2/1
Hypopharynx ($n = 847$)	70	2/0	80/13	51/4	20/3	24/2	3/1
Supraglottic larynx ($n = 428$)	55	2/0	71/21	48/10	18/7	15/4	2/0
Nasopharynx ($n = 440$)	80	9/5	71/56	36/32	22/15	32/26	15/10

[a] Redrawn from Refs. [3,28,49].
[b] Parotid, buccal nodes.
[c] Ipsilateral/contralateral nodes.

Metastatic lymph node involvement in the neck depends on the size of the primary tumors, increasing with the T stage. In the series of Bataini, 44% of patients with a T1 tumor had clinical lymph nodes involvement; it increased up to 70% for patients with T4 lesions [3]. There are, however, no data suggesting that the relative distribution of involved neck levels varies with the T stage.

3.1.2. Retropharyngeal lymph nodes

Retropharyngeal lymph nodes are nodes lying within the retropharyngeal space which extends cranially from the base of skull to the level of C3, caudally. This space is bounded anteriorly by the pharyngeal constrictor muscles and posteriorly by the prevertebral fascia [26,44]. Typically, retropharyngeal nodes are divided into medial and lateral groups. The medial group is an inconsistent group which consists of one to two lymph nodes intercalated in or near the midline. The lateral group lies medial to the carotid artery. The most superior lymph node of this group is also called the lymph node of Rouvière.

Retropharyngeal lymph nodes represent a special entity inasmuch as that they are usually not clinically detectable. The incidence of retropharyngeal lymph nodes involvement can thus only be estimated from series in which imaging with CT or MR of the retropharynx was systematically performed as part of the diagnostic work-up procedure. A summary of the available data on the incidence of retropharyngeal lymph node infiltration is presented in Table 3 [12,14,33]. In all these studies, lymph nodes were studied by CT and/or MRI and were considered involved when they reached a size of more than 10 mm or showed central necrosis irrespective of the size. Retropharyngeal node involvement occurs in primary tumors arising from (or invading) mucosa derived from occipital and cervical somites such as the nasopharynx, the pharyngeal wall and the soft palate. Interestingly, the incidence of retropharyngeal lymph nodes is higher in patients in whom involvement of other neck node levels was also documented. In N0 patients with nasopharyngeal tumors and to a lesser extent in patients with pharyngeal wall tumors, the incidence of retropharyngeal nodes however still reaches substantial figures between 16 and 40%. Also, as already described for the other lymph node levels, involvement depends on the T stage, being typically lower for T1 tumors.

3.2. Distribution of pathologically involved lymph nodes in the neck

In the previous studies, the pattern of metastatic node involvement was established from the sole clinical palpation of the neck. It is likely that the use of modern imaging modalities would slightly change the reported figures. Indeed, systematic use of CT scan, MRI or ultrasound has increased both the sensitivity and the specificity of detection of macroscopic neck node involvement [53,60,61]. However, even with the use of these modern imaging modalities, there is no reliable diagnostic tool available to detect microscopic neck involvement in those patients with clinically or radiologically negative nodes. In this regard, hope has been put on ultrasound guided fine-needle aspiration. Recent multicenter evaluation, however, failed to demonstrate a significant added value of this procedure over CT or MRI [57]. To establish guidelines for the definition of target volumes in the neck of patients with primary tumors of the head and neck, a true estimate of the pattern of macroscopic as well as microscopic metastatic node distribution is needed. In particular, information on the incidence of microscopic neck involvement in levels contiguous to those with macroscopic node involvement, and an estimate of the frequency of microscopic skip metastasis, are necessary.

Table 3
Incidence of retropharyngeal lymph nodes in head and neck primary tumors

Authors	Primary site	Incidence of retropharyngeal lymph nodes (percentage of the total number of patients)		
		Overall	N0 neck[a]	N+ neck[b]
McLaughlin et al. [33]	Oropharynx			
	Pharyngeal wall	18/93 (19[c])	6/37 (16)	12/56 (21)
	Soft palate	7/53 (13)	1/21 (5)	6/32 (19)
	Tonsillar fossa	16/176 (9)	2/56 (4)	14/120 (12)
	Base of tongue	5/121 (4)	0/31 (0)	5/90 (6)
	Hypopharynx (pyriform sinus or postcricoid area)	7/136 (5)	0/55 (0)	7/81 (9)
	Supraglottic larynx	4/196 (2)	0/87 (0)	4/109 (4)
	Nasopharynx	14/19 (74)	2/5 (40)	12/14 (86)
Chua et al. [14]	Nasopharynx	106/364 (29)	21/134 (16)	85/230 (37)
Chong et al. [12]	Nasopharynx	Not stated	Not stated	59/91 (65)

[a] Clinically negative nodes in levels I–V.
[b] Clinically positive nodes in levels I–V.
[c] Numbers in parentheses are in percentages.

Table 4
Incidence (%) of pathologic lymph node metastasis in squamous cell carcinomas of the oral cavity[a]

Tumor site	Distribution of metastatic lymph nodes per level (percentage of the neck dissection procedures)											
	Prophylactic RND[b] (192 patients; 192 procedures)						Therapeutic (immediate or subsequent) RND (308 patients; 323 procedures)					
	No. of RNDs	I[c]	II	III	IV	V	No. of RNDs	I	II	III	IV	V
Tongue	58	14	19	16	3	0	129	32	50	40	20	0
Floor of mouth	57	16	12	7	2	0	115	53	34	32	12	7
Gum	52	27	21	6	4	2	52	54	46	19	17	4
Retromolar trigone	16	19	12	6	6	0	10	50	60	40	20	0
Cheek	9	44	11	0	0	0	17	82	41	65	65	0
Total	192	20	17	9	3	1	323	46	44	32	16	3

[a] Redrawn from Ref. [48].
[b] Radical neck dissection.
[c] I–V are in percentages.

3.2.1. Incidence of pathologic lymph nodes metastasis in levels I–V

The Head and Neck Service at Memorial Sloan-Kettering Cancer Center has established the pattern of cervical lymph node metastasis from 1081 previously untreated patients undergoing 1119 radical neck dissections between 1965 and 1986 for tumors of the oral cavity, oropharynx, hypopharynx and larynx [10,11,47,48]. This group is part of the 2665 patients who underwent radical neck dissection during the same period for squamous cell carcinomas of the upper aerodigestive tract. The remaining 1584 patients were excluded from the retrospective analysis because of previous surgery, radiotherapy or chemotherapy. Patients with clinically positive nodes at diagnosis were treated by an immediate therapeutic radical neck dissection. Patients with clinically negative nodes were treated either by a prophylactic radical neck dissection at the time of diagnosis, or a subsequent therapeutic radical neck dissection at the time when a node developed during the follow-up. The reason for immediate vs. delayed radical neck dissection in N0 patients was not specified. Presumably, some of these patients were thought to be at higher risk of microscopic involvement (e.g. T3–T4 vs. T1–T2 tumors, pharyngeal primary) in the judgment of the surgeon. It is likely that during the same period, other patients were referred to the Memorial Sloan-Kettering Cancer Center with the diagnosis of squamous cell carcinoma of the upper aerodigestive tract, but were not proposed a radical neck dissection as part of their treatment. Although this retrospective study is thus possibly biased, it represents so far the only large study from which metastatic node distribution in levels I–V of the neck can be established in patients with primaries of the oral cavity, oropharynx, hypopharynx and larynx.

The results of this retrospective study are showed in Tables 4–7. The data are presented as the number of neck dissections with positive lymph nodes over the total neck dissection procedures, and expressed as percentage. In the 341 patients with a clinically N0 neck, 343 neck dissections were performed, meaning that a bilateral dissection was only performed in two patients (<1%). In the 736 patients with clinically positive nodes, bilateral neck dissection was performed in 39 patients (5%) with either bilateral nodes at palpation or midline tumors. In both groups, the pathologic evaluations of the neck dissections were pooled together, so that distinction between the ipsilateral and contralateral neck could not be performed.

Overall, metastatic disease was confirmed in 33% of the prophylactic neck dissections and in 82% of the therapeutic neck dissections. In this series, the overall sensitivity and specificity of the clinical examination thus reached 85 and

Table 5
Incidence (%) of pathologic lymph node metastasis in squamous cell carcinomas of the oropharynx[a]

Tumor site	Distribution of metastatic lymph nodes per level (percentage of the neck dissection procedures)											
	Prophylactic RND (47 patients; 48 procedures)						Therapeutic (immediate or subsequent) RND (157 patients; 165 procedures)					
	No. of RNDs	I[b]	II	III	IV	V	No. of RNDs	I	II	III	IV	V
Base of tongue + vallecula	21	0	19	14	9	5	58	10	72	41	21	9
Tonsillar fossa	27	4	30	22	7	0	107	17	70	42	31	9
Total	48	2	25	19	8	2	165	15	71	42	27	9

[a] Redrawn from Ref. [10].
[b] I–V are in percentages.

Table 6
Incidence (%) of pathologic lymph node metastasis in squamous cell carcinomas of the hypopharynx[a]

Tumor site	Distribution of metastatic lymph nodes per level (percentage of the neck dissection procedures)											
	Prophylactic RND (24 patients; 24 procedures)						Therapeutic (immediate or subsequent) RND (102 patients; 104 procedures)					
	No. of RNDs	I[b]	II	III	IV	V	No. of RNDs	I	II	III	IV	V
Pyriform sinus	13	0	15	8	0	0	79	6	72	72	47	8
Pharyngeal wall	11	0	9	18	0	0	25	20	84	72	40	20
Total	24	0	12	12	0	0	104	10	75	72	45	11

[a] Redrawn from Ref. [10].
[b] I–V are in percentages.

62%, respectively. As already observed with the pattern of the clinical metastatic lymph nodes, the distribution of pathological confirmed metastatic lymph nodes depended on the primary tumor site. Typically, in clinically N0 patients, metastatic lymph nodes were observed in levels I–III for oral cavity tumors and in levels II–IV for oropharyngeal, hypopharyngeal and laryngeal tumors. This pattern of node distribution is similar to the one determined from the clinical palpation of the neck. It should be noted that the T-stage distribution was different in the various groups. Patients with laryngeal tumors had 54% (42/79) of T3–T4 tumors (mainly supra-glottic) compared with 27% (52/192), 25% (6/24), and 17% (8/47) in patients with oral cavity, hypopharyngeal and oropharyngeal tumors, respectively. Such a difference in T stage presumably explains the high incidence of node metastasis in the larynx group. When considering the patients who underwent a therapeutic neck dissection, the pattern of metastatic node distribution was similar to the one observed in N0 patients, with the difference that significant pathologic infiltration of an extra level was typically observed, i.e. the level IV for oral cavity tumors and the level I and V for oropharyngeal, hypopharyngeal, and to a lesser extent laryngeal tumors. Overall, this observation illustrates the gradual infiltration of node levels in the neck. In the Memorial Sloan-Kettering series, pathological infiltration of level V was quite low, peaking at 11% for hypopharyngeal tumors with pathological positive nodes (Table 6) [17]. A thorough analysis showed that a single infiltration of level V was only observed in one patient (0.2%) with a hypopharyngeal tumor. Infiltration in level V remained below 1% when a single pathologically confirmed positive node was also observed in levels I–III, but reached 16% when a single pathologically confirmed positive node was also observed in level IV. When more than one level was infiltrated, the probability of level V involvement progressively increased reaching 40% when levels I–IV were all involved. The pattern of involvement of level I is also a good illustration of the concept of gradual node infiltration. In the Memorial Sloan-Kettering series, pathological involvement of level I was only found in 2% of clinical N0 patients with oropharyngeal tumors (Table 5) and was not observed in clinical N0 patients with hypopharyngeal tumors (Table 6). On the other hand, in patients with clinically positive nodes, metastases in level I were reported in 15 and 10% of patients with oropharyngeal and hypopharyngeal tumors, respectively. Similar findings on metastasis in levels I and V have been reported by others [1,16,18,45,51,52]. Lastly, one should also mention that in this group of patients with therapeutic neck dissection, patients with laryngeal tumors had also more advanced T-stage tumors as observed for patients with prophylactic neck dissection.

Anticipating the conclusions that could be drawn from the Memorial Sloan-Kettering Cancer Center data with regard to the neck dissection procedure, several groups have been performing selective neck dissection already since the 1950s [6,7,13,24,25,29,34,37,40,55]. Typically, for tumors

Table 7
Incidence (%) of pathologic lymph node metastasis in squamous cell carcinomas of the larynx[a]

Tumor site	Distribution of metastatic lymph nodes per level (percentage of the neck dissection procedures)											
	Prophylactic RND (78 patients; 79 procedures)						Therapeutic (immediate or subsequent) RND (169 patients; 183 procedures)					
	No. of RNDs	I[b]	II	III	IV	V	# RND	I	II	III	IV	V
Supraglottic larynx	65	6	18	18	9	2	138	6	62	55	32	5
Glottic larynx	14	0	21	29	7	7	45	9	42	71	24	2
Total	79	5	19	20	9	3	183	7	57	59	30	4

[a] Redrawn from Ref. [11].
[b] I–V are in percentages.

of the oral cavity, and to a lesser extent for oropharyngeal tumors, dissection of levels I–III (supraomohyoid neck dissection) was performed, whereas for laryngeal and hypopharyngeal tumors, dissection of levels II–IV (lateral neck dissection) or II–V (posterolateral neck dissection) was performed. Such selective neck procedures were initially proposed for clinically node-negative patients, and later on extended to clinically node-positive patients. These studies are, however, biased as the patients treated by a selective procedure were probably highly selected with regard to the tumor site, tumor stage and nodal status. In addition, in the majority of these patients, postoperative radiotherapy was usually performed in case of a high risk of neck failure, e.g. multiple node involvement, large node infiltration or extracapsular spread. It is likely that the irradiated field encompassed those node levels that were not dissected but that could be at risk for microscopic infiltration.

Having these limitations in mind, in some of these studies the level of the neck recurrence was reported allowing an estimate of the failure rate in the neck inside and outside the dissected levels [5–7,13,37,40,55]. In four of these studies, neck recurrence was reported only in patients with the primary tumor controlled, excluding thus neck recurrence from reseeding from the recurrent primary [6,7,37,40,55]. In summary, after supraomohyoid or lateral neck dissections, the rate of neck failure in undissected levels was low and typically below 10%. In the study of Chu, a high failure rate of 29% was however reported after a dissection that only removed levels I and II (suprahyoid dissection) for tumors of the oral cavity. All these figures can be considered as good estimates of the microscopic involvement in the undissected levels at the time of the neck dissection. They are in good agreement with the data reported from the Memorial Sloan-Kettering Cancer Center.

Recently, the Brazilian Head and Neck Cancer Study Group reported the results of a randomized trial on modified radical vs. supraomohyoid neck dissection for clinically node negative patients with T2–T4 tumors of the oral cavity [5]. Postoperative radiotherapy was indicated in the case of positive margin at the resection of the primary tumors and/or positive lymph nodes. With 64 patients in each group, the 5-year actuarial overall survival reached 63 and 67% in the modified radical neck dissection group and in the supraomohyoid neck dissection group, respectively. Failure in the neck occurred in six patients (9%) in each group. In the supraomohyoid neck dissection group, three patients (4.5%) had neck recurrence outside the dissected levels.

In theory, incidence and distribution of neck node metastasis in clinically N0 patients could also be indirectly inferred from neck recurrence outside the irradiated volume in patients treated by radiotherapy. In external radiotherapy, however, typical fields were used to encompass all node levels on both sides of the neck with only few exception, e.g. small laryngeal tumors. In addition, in external radiotherapy series, a pattern of failure does usually not separate in-field from out-field recurrences. Thus adequate sources of data mainly come from patients treated on the sole primary tumors, usually with brachytherapy. In brachytherapy series, only limited data for oral cavity tumors are available. Pernot reported a series of 346 carcinomas of the oral cavity (floor of mouth and mobile tongue) treated by brachytherapy of whom 227 clinically N0 patients did not have any treatment on the neck [38]. The majority of these patients had T1 tumors. The rate of regional failure alone reached 16% (14% for T1 and 28% for T2) but no information on the distribution of the recurrent node was available. Piedbois reported similar results in a series of 223 patients with stage I or II carcinoma of the oral cavity (floor of mouth and mobile tongue) treated with brachytherapy for the primary [39]. Out of the 123 patients who did not have a neck dissection at the time of the primary treatment, 13% (11% for stage I and 25% for stage II) presented a neck failure alone. Again, no information on the distribution of the recurrent node was available. The subset of patients with floor of mouth tumors from the same institution was further analyzed with similar findings [32]. An old series from Stanford reported a rate of neck failure of 38% in 164 clinically N0 patients treated by radium implants for oral cavity tumors [20]. It should be noted that in the series mentioned above, patients with no neck treatment typically had small T1 or T2 tumors and were highly selected. Besides, because no data were available on the distribution of the node failure, these series are of limited value to assess the node levels to be treated. However, on average, the reported rates of neck failure are in agreement with the pathological data presented in Table 4.

For nasopharyngeal carcinomas, analysis of the pattern of failure in a large series of 5037 patients treated by external radiotherapy indirectly indicated the incidence of microscopic neck involvement in clinically N0 patients [27]. In this series, 906 patients did not receive prophylactic irradiation in levels I–V. Among them, 362 (40%) had a nodal relapse. It is, however, not known how many of these patients also had a local relapse, and the distribution of the node failure in the neck was not stated.

3.2.2. Frequency of 'skip metastases' in the neck

'Skip metastases' are those metastases that bypass the orderly progression from one level to a contiguous level, e.g. from level I to level II, and from level II to level III. Depending on their frequency, 'skip metastases' in patients clinically staged N0 may have profound implications on the therapeutic management of the neck. In the series from the Memorial Sloan-Kettering Cancer Center, eight of 343 clinically N0 patients (2.5%) developed 'skip metastases' [47]. Seven of these patients had oral cavity tumors that metastasized in level IV or V only. One patient had a laryngeal tumor. These low figures are in good agreement with a rate of neck failure outside the dissected levels of 3% (2/64) observed in pathological N0 patients treated in the same institution by a supraomohyoid neck dissection [55]. The majority of these patients had tumors of the oral cavity. None of them received

Table 8
Incidence of pathologic retropharyngeal lymph node metastases in head and neck primary tumors

Authors	Primary site	Incidence of retropharyngeal lymph nodes (percentage of the total number of patients)		
		Overall	pN0 neck[a]	pN + neck[b]
Ballantyne [2]	Oropharynx (pharyngeal wall)	15/34 (44[c])	n.a.	n.a.
Hasegawa and Matsuura [22]	Oropharynx	4/11 (36%)	1/2 (50%)	3/9 (33%)
	Hypopharynx	8/13 (62%)	0/3 (0%)	9/10 (90%)
Okumura et al. [36]	Oropharynx + hypopharynx	6/42 (14%)	Not stated	Not stated
Byers et al. [7]	Oropharynx (pharyngeal wall)	2/45 (4%)	Not stated	Not stated

[a] Pathologically negative nodes in levels I–V.
[b] Pathologically positive nodes in levels I–V.
[c] Numbers in parentheses are in percentages.

postoperative radiotherapy as they were all free of metastasis. Byers et al. carefully evaluated the frequency of 'skip metastases' in 270 patients primarily treated by surgery at M.D. Anderson Cancer Center from 1970 to 1990 for squamous carcinoma of the oral tongue [9]. Of these patients, 12 had metastases in level III only, nine had metastases in level IV only and two had metastases in level IIb (i.e. nodes that are far enough posterior to the internal jugular vein). In addition, in 90 of these patients which were pathologically N0 and did not receive postoperative radiotherapy, nine subsequently developed recurrence in level IV which had not been dissected or irradiated. Altogether (level IIb, III and IV) the frequency of skip metastases reached 12% (32/270). If one excludes the 'skip metastases' in level III, the frequency reaches 7.5% (20/270).

3.2.3. Incidence of pathologic retropharyngeal lymph nodes

Retropharyngeal lymph nodes are usually not included in standard neck dissection procedure, and only limited data are thus available on the incidence of pathologic involvement of retropharyngeal lymph nodes (Table 8). As early as 1964, Ballantyne reported a series of 34 patients with pharyngeal wall tumors in whom a retropharyngeal node dissection was performed [2]. Pathological involvement of retropharyngeal nodes was observed in 15 patients (44%) of whom 13 had also pathological involvement in other levels in the neck. Ballantyne also reported pathological retropharyngeal node involvement in 11 other patients with oropharyngeal, hypopharyngeal and oral cavity tumors. In this series, no information on the TNM stage was provided, but it is likely that it included selected patients with locally advanced tumors. More recently, two consecutive series from the same Japanese hospital were reported [22,36]. These patients were probably highly selected with locally advanced (stage III and IV) oropharyngeal and hypopharyngeal tumors. Pathologic retropharyngeal lymph nodes were reported in 12 of 24 patients (50%), and in six of 42 patients (14%). Interestingly, comparison of the pathologic specimens with the preoperative imaging diagnosis with CT or MRI indicated a high sensitivity (83% for CT and 100% for MRI) and specificity (100% for both CT and MRI) of the radiological examination [36]. Byers et al. also reported pathologic retropharyngeal lymph node involvement in two of 45 clinical N0 patients with pharyngeal wall tumors [7]. Again, these patients were highly selected and the reported figures probably do not represent the true estimate of pathological involvement in retropharyngeal lymph nodes.

3.2.4. Incidence of anterior cervical lymph nodes

This group of lymph nodes included in level VI comprises the paratracheal, pretracheal, precricoid and perithyroid nodes and the nodes along the recurrent nerves. These nodes drain the subglottic larynx, the upper esophagus, the piriform sinus, the thyroid gland and the cervical trachea [62,64]. The incidence of anterior cervical lymph node metastasis is poorly documented. In subglottic cancer, it has been reported that paratracheal lymph nodes may be pathologically involved in 50% of the cases [21].

3.2.5. Pattern of node distribution in the contralateral neck

There are very few data on the pattern of pathological node distribution in the contralateral neck. Bilateral neck dissection was only performed when the risk of contralateral node involvement was considered high in the surgeon judgment, e.g. tumor of the oral cavity or the oropharynx reaching or extending beyond the midline, hypopharyngeal and supraglottic tumors. Obviously, in such cases, bilateral radical neck dissection was never performed, so that an accurate estimate of the pattern of node involvement in levels I–V of the contralateral neck is not possible. Furthermore, in almost every study, data of both side of the neck were pooled together for presentation. Kowalski presented data on 90 patients who underwent a bilateral supraomohyoid neck dissection, and in whom the pattern of node distribution in each side of the neck was reported separately [25]. The majority of these patients had squamous cell carcinoma of the lip or the oral cavity. In the ipsilateral neck, pathologic infiltration in levels I, II and III reached 20, 15 and 15%, respectively. In the contralateral neck, corresponding values reached 13, 11 and 0%, respectively. These figures are in good agreement with data on the clinical node distribution showing that both sides of the neck exhibited a similar pattern of node distribution, but with a lower incidence in the contralateral neck. Foote reported the rate of contralateral neck failure in a limited series of 46 clinically N0 patients with base of tongue tumors treated with some form of glossectomy and ipsilateral neck dissection [19]. None of these patients received postoperative radiotherapy. Ten patients (22%) had a contralateral neck recurrence, and the most common sites were in levels II, III and IV. It appears that two of these patients also experienced recurrence at the primary site. The development of delayed contralateral neck metastases was not related to the clinical or pathological extent of the base of tongue tumor.

4. Guidelines for the selection of the target volumes in the neck

The data presented in the previous section indicated that metastatic lymph node involvement of primary squamous cell carcinomas of the oral cavity, pharynx and larynx typically followed a predictive pattern. Both data on clinical and pathological neck node distribution, and on neck recurrence after selective dissection procedures, supported the concept that not all the neck node levels should be treated as part of the initial management strategy of head and neck primaries of squamous cell origin [8,15]. One has to bear in mind, however, that the data from which such a concept is derived are fraught with possible bias that might limit its validity.

First, all the reported series but one are retrospective studies which only included selected patients. As already pointed out, in the large series of the Memorial Sloan-Kettering Cancer Center on pathological node distribution, only 42% of patients who underwent a radical neck dissection were reviewed [47]. During the period of study, less radical procedures were also performed in the same institution, but the selection criteria were not explicitly described. Similar comments can be made for the series from M.D. Anderson Cancer Center regarding the selection criteria for the selective neck dissection procedures. The T stage was probably one of the most important selection criteria in these retrospective studies. It has to be kept in mind that in the Memorial Sloan-Kettering Cancer Center, larger tumors were included in the pharyngeal and laryngeal tumor groups in comparison with oral cavity tumors, and the incidence of microscopic metastasis is likely to be influenced by the T stage. An unequivocal demonstration of the similitude of radical or radical modified and selective neck dissection procedures (or extended vs. localized neck irradiation) would require multicenter randomized trials where patients are balanced with regard to tumor site, tumor stage and the use of postoperative radiotherapy between treatment groups. The only trial addressing this question failed to demonstrate any difference between the two arms, but its statistical power was not strong enough to demonstrate subtle differences [5].

Second, all the figures on pathological involvement of the neck or regional failures after selective treatment are largely based on palpation only, and the impact of modern imaging techniques on treatment strategy for the neck have not yet been fully investigated. It is likely that the systematic use of imaging will result in a upstaging of the neck nodes especially in obese patients, or for deeply located nodes. Whether this will decrease the incidence and modify the distribution of the metastatic neck nodes is still unknown.

Third, although neck dissection procedures have been well defined, minor variants were reported by the surgical teams. In the supraomohyoid neck dissections, Byers reported that lymph nodes located in level IIb were also at risk for microscopic infiltration in squamous carcinomas of the tongue [6,7]. Apparently, dissection on level IIb is not always performed in a supraomohyoid neck dissection. Such practice might thus artificially increase the estimate of the true rate of neck failure outside the dissected levels.

Fourth, in almost all series of selective neck dissection, some patients received postoperative radiotherapy on the basis of characteristics of the primary tumor (e.g. positive margins) or the neck specimen (e.g. extracapsular rupture, more than one infiltrated node). The radiation fields were not described, but it is likely that areas of possible microscopic involvement outside the dissected levels were irradiated. Such management might thus artificially decrease the true estimate of the rate of neck failure outside the dissected levels.

Fifth, the incidence of retropharyngeal and paratracheal node infiltration cannot be adequately estimated from the literature data. These node areas can only be evaluated by imaging and such a study has only rarely been performed, especially for paratracheal nodes. The few series on pathological infiltration reported a very high rate of infiltration in these lymph nodes. Unfortunately, selection criteria of those patients who underwent retropharyngeal or paratracheal node dissection were never mentioned.

Finally, the concept of selective neck treatment in head and neck squamous cell primaries is mainly drawn from data collected in large institutions having extended experience in the management of such cancer patients. Knowledge, experience and technical judgment of the clinicians implicated in the treatment of these patients cannot thus be underestimated. Implementation of guidelines for selective neck treatment in smaller institutions therefore need to be performed with great caution in the best interest of the patients. More than ever, one should emphasize the fact that the management of head and neck cancer patients has to be restricted to those institutions with greater experience and where a multidisciplinary oncologic approach can be offered.

With all these limitations in mind, tentative guidelines for the selection of the appropriate neck node levels to be treated are proposed. It is assumed that the staging of the neck has been done appropriately using clinical and radiological examination including at least CT or MRI. Following the methodology developed by the European 'State of the Art in

Oncology' (START) project, the level of evidence of these recommendations is based on rational inference, i.e. from available data and knowledge combined together, but without indisputable proof resulting from randomized trials or well accepted meta-analysis (see http://www.cancereurope.net/start/web/methodology.cfm).

In reading these guidelines, the following limitations must be understood.

- These guidelines do not intend to give recommendations on the optimal strategy (observation vs. prophylactic treatment) for patients with a clinically N0 neck. Such a decision remains at the discretion of the multidisciplinary head and neck tumor board. It has been proposed from decision analysis trees that a treatment of the N0 neck is warranted if the probability of occult cervical metastasis is higher than 20% [63]. This is a very high figure that is likely not to be adopted in the majority of the European centers, which would probably treat the neck when the probability of occult metastasis is higher than 5–10%. Tumor size and depth of infiltration, tumor grade, and tumor site are the most important risk factors for lymph nodes metastasis that should be taken into consideration for treatment decision [49].
- These guidelines do not intend to give recommendations on the respective use of radiotherapy or neck dissection in the management of the neck of patients with head and neck squamous cell carcinomas. The choice between radiotherapy and surgery need to be considered in light of the neck stage, the treatment options of the primary tumor, the performance status of the patient, and the local policy agreed upon in a multidisciplinary head and neck tumor board.
- These guidelines do not apply to the treatment of recurrent neck after primary radiotherapy or surgery. In the neck previously violated, lymph node drainage is modified, and the pattern of neck node infiltration follows rather unpredictable pathways.
- These guidelines are not immutable and should be adapted according to results of forthcoming studies. e.g. a randomized trial of selective vs. radical modified treatment of the neck in clinically N0 patients.

For N0 patients with head and neck squamous cell carcinoma of oral cavity, oropharynx, hypopharynx and larynx, selective treatment of the neck is appropriate (Table 9) [6,15,55]. Typically, levels I–III should be treated for oral cavity tumors, and levels II–IV for oropharyngeal, hypopharyngeal and laryngeal tumors. Recently, Robbins has suggested that elective treatment of level IIb is probably not necessary for N0 patients with a primary tumor in the oral cavity, larynx or hypopharynx [42]. On the other hand, Byers et al. suggested inclusion of level IV in the treatment of mobile tongue due to the high incidence (10%) of skip metastases [9]. Retropharyngeal nodes should be treated in tumors of the posterior pharyngeal wall. For subglottic tumors, tumors with subglottic or transglottic extension, or hypopharyngeal tumors with esophageal extension, paratracheal nodes should also be included in the treatment volume. For nasopharyngeal tumors, levels I–V and retropharyngeal nodes need to be treated even for N0 patients. As proposed by Byers, similar guidelines could also be recommended for N1 patients without suspicion of extracapsular infiltration (Table 9) [6].

For patients with multiple nodes (N2b), available data suggest that adequate treatment should include levels I–V (Table 9). Level I could, however, be omitted for laryngeal tumors, and level V for oral cavity tumors with neck involvement limited to levels I–III. Prophylactic treatment of the retropharyngeal nodes should be systematically performed for oropharyngeal and hypopharyngeal tumors. As for N0 patients, level VI nodes should also be treated for subglottic tumors, tumors with subglottic or transglottic extension, or hypopharyngeal tumors with esophageal extension.

There are no data on the distribution of pathological metastatic neck nodes in patients presenting with a single ipsilateral large node (N2a or N3) or with bilateral or contralateral nodes (N2c), and thus no recommendation can be made. For N3 patients, the treatment of the neck is likely to be dictated by the local extension of the node into adjacent structures (e.g. paraspinal muscles, parotid gland, blood vessels, etc.). For N2c patients, one proposal is to consider each side of the neck separately, e.g. selective treatment on both sides for a small single node on each side, selective treatment for a small single node on one side, and more extensive treatment on the other side in cases of multiple nodes.

Table 9
Suggested guidelines for the treatment of the neck of patients with head and neck squamous cell carcinomas (AJCC 1997)

Location of primary tumor	Appropriate node levels to be treated	
	Stage N0–N1	Stage N2b
Oral cavity	I, II, and III (+IV for anterior tongue tumors)	I, II, III, IV and V[a]
Oropharynx	II[b], III, and IV (+retropharyngeal nodes for posterior pharyngeal wall tumors)	I, II, III, IV, V and retropharyngeal nodes
Hypopharynx	II[b], III, and IV (+VI for esophageal extension)	I, II, III, IV, V and retropharyngeal nodes (+VI for esophageal extension)
Larynx[c]	II[b], III, and IV (+VI for transglottic and subglottic tumors)	(I), II, III, IV and V (+VI for transglottic and subglottic tumors)
Nasopharynx	II, III, IV, V, and retropharyngeal nodes	II, III, IV, V, and retropharyngeal nodes

[a] May be omitted if only levels I–III are involved.
[b] Nodes in level IIb could be omitted for N0 patients.
[c] T1 glottic cancer excluded.

Treatment of the contralateral neck is still in the gray zone and is likely to result from clinical judgment rather than from strong scientific evidence. Typically, patients with midline tumors or tumors originating from or extending to a site which has a bilateral lymphatic drainage (e.g. base of tongue, vallecula) are thought to benefit from a contralateral treatment, whereas well-lateralized tumors (e.g. lateral border of tongue, retromolar trigone) will be spared from contralateral treatment. It has also been reported in tumors of the pharynx and larynx that the risk of contralateral neck metastasis increased with involvement of the ipsilateral neck [30]. The only recommendation that can be made regarding the treatment of the contralateral neck is that the selection of the node levels to be treated should follow similar rules to those for the ipsilateral neck.

In principle, similar philosophy should apply for the definition of the node levels to be irradiated postoperatively. However, if one agree on the selection criteria for postoperative radiotherapy (i.e. capsular rupture, patients with a metastatic node higher than 3 cm in diameter or with more than one metastatic node), irradiation of levels I–V will be typically performed. For laryngeal tumors, level I could be omitted. For oral cavity tumors, postoperative irradiation of level V could be omitted in the case of metastatic nodes located in level I and/or II only. Retropharyngeal and paratracheal nodes should be treated as mentioned above.

5. Guidelines for the delineation of the target volumes in the neck

As already discussed in Section 2, the Committee for Head and Neck Surgery and Oncology of the American Academy for Otolaryngology – Head and Neck Surgery has recommended the use of a common terminology and procedures for the surgical treatment of the neck [41]. We propose to use similar recommendations for the treatment of the neck by radiotherapy.

Radical neck irradiation would become the reference procedure where levels I–V are included in the target volume along with the internal jugular vein, the spinal accessory nerve, and the sternocleidomastoid muscle. Such a procedure is only recommended in case of infiltration of the sternocleidomastoid muscle and/or infiltration or thrombosis of the internal jugular vein as illustrated on CT or MR images, or confirmed on pathological examination. The modified radical neck irradiation with preservation of the sternocleidomastoid muscle would in fact become the standard procedure. In theory, the internal jugular vein and the spinal accessory nerve should also be spared by this procedure. In practice, it will be almost impossible to exclude the internal jugular vein and the spinal accessory nerve from the target volume. Similarly, the carotid artery, which is not removed during a neck dissection procedure (unless there is a carotid wall infiltration), will always be included in the target volume. On the other hand, the fascia of the sternocleidomastoid muscle on the cutaneous side which is dissected off the muscle during a modified radical neck dissection will not be included in the target volume for the obvious reason of skin protection. However, the few lymph nodes included in this fascia will probably be substantially irradiated irrespective of the technique used. Selective neck irradiation would be the procedure when not all levels are included in the target volume. This includes supraomohyoid neck irradiation (levels I–III), lateral neck irradiation (levels II–IV), and posterolateral neck irradiation (levels II–V). Lastly, we do not recommend the use of the 'extended neck irradiation' terminology. Rather, we would prefer to describe the irradiation of other lymphatic or non-lymphatic structures separately. Irradiation of levels II–IV and retropharyngeal nodes would be called lateral neck irradiation extended to the retropharyngeal nodes. Irradiation of levels I–V, the parotid gland and the retropharyngeal nodes would be called a radical modified neck irradiation extended to the parotid and the retropharyngeal nodes.

The use of such terminology implies that radiation oncologists agree on the use of a standardized procedure for the delineation of the various node levels in the neck. We recommend to use similar anatomical boundaries to those proposed by Robbins for levels I–VI, and to extend the concept of node levels to those nodes not covered by the Robbins' classification, i.e. in the retropharyngeal space. The anatomical limits defined by Robbins, however, need to be slightly adapted to take into account the radiological information easily derived from CT or MRI axial sections. In particular, such imaging-based nodal classification needs to address the following specific points: (1) what are the radiological cranial limits of level II and the relationship between those nodes and the retropharyngeal nodes? (2) how does one consistently define the radiological caudal limits of levels IV and V on axial sections? and (3) what are the radiological limits that divide levels IIa and IIb, and levels Va and Vb?

Table 10 proposes recommendations for the delineation of the various node levels in the neck. These recommendations are based on the imaging classification of cervical nodes proposed by Som et al. and critically reviewed by Robbins [43,54]. There are in good agreement with those proposed by Nowak et al. [35]. Cross-sectional atlases of head and neck nodes have been also recently published [23,31,56]. For the sake of our demonstration, these are of limited use, as they did not precisely define the anatomical boundaries of the various nodal spaces. In Table 10, the boundaries refer to a patient lying in supine position with his head in 'neutral' position. The terms 'cranial' and 'caudal' refer to structures close to the cephalic and feet end, respectively. The terms 'anterior' and 'posterior' were preferred to the terms 'ventral' and 'dorsal', respectively. Examples of delineated node levels are shown in Figs. 1 and 2. It needs to be emphasized that the volumes delineated in these diagrams correspond to the clinical target volume (CTV), and hence do not include margins for organ motion or setup inaccuracy.

Table 10
Recommendations for the radiological boundaries of the neck node levels

Level	Anatomical boundary					
	Cranial	Caudal	Anterior	Posterior	Lateral	Medial
Ia	Geniohyoid m.	Platysma m.	Symphysis menti; platysma m.	Body of hyoid bone	Medial edge of anterior belly of digastric m.	n.a.[a]
Ib	Mylohyoid m., cranial edge of submandibular gland or caudal edge of medial pterygoid m.	Platysma m.	Symphysis menti	Body of hyoid bone; posterior edge of submandibular gland	Basilar edge of mandible; platysma m.	Lateral edge of anterior belly of digastric m.
II	Bottom edge of the body of C1	Bottom edge of the body of hyoid bone	Posterior edge of submandibular gland; posterior edge of posterior belly of digastric m.	Posterior border of sternocleidomastoid m.	Medial edge of sternocleidomastoid m.	Internal edge of internal carotid artery, paraspinal (levator scapulae) m.
III	Bottom edge of the body of hyoid bone	Bottom edge of cricoid cartilage	Posterolateral edge of sternohyoid m.	Posterior edge of sternocleidomastoid m.	Medial edge of sternocleidomastoid m.	Internal edge of carotid artery, paraspinal (scalenius) m.
IV	Bottom edge of cricoid cartilage	Cranial border of clavicle	Posterolateral edge of sternohyoid m.	Posterior edge of sternocleidomastoid m.	Medial edge of sternocleidomastoid m.	Internal edge of internal carotid artery, paraspinal (scalenius) m.
V	Skull base	Cranial border of clavicle	Posterior edge of sternocleidomastoid m.	Anterior border of trapezius m.; scalenius m.	Platysma m.; skin	Paraspinal (levator scapulae, splenius capitis) m.
VI	Bottom edge of the body of hyoid bone	Sternal manubrium	Skin; platysma m.	Posterolateral edge of sternohyoid m.	Medial edge of common carotid artery, skin and anterior–medial edge of sternocleidomastoid m.	n.a.
Retro-pharyngeal	Base of skull	Cranial edge of the body of hyoid bone	Levator veli palatini m.	Prevertebral m. (longus colli, longus capitis)	Medial edge of internal carotid artery	Midline

[a] Midline structure lying between the medial borders of the anterior belly of the digastric muscle.

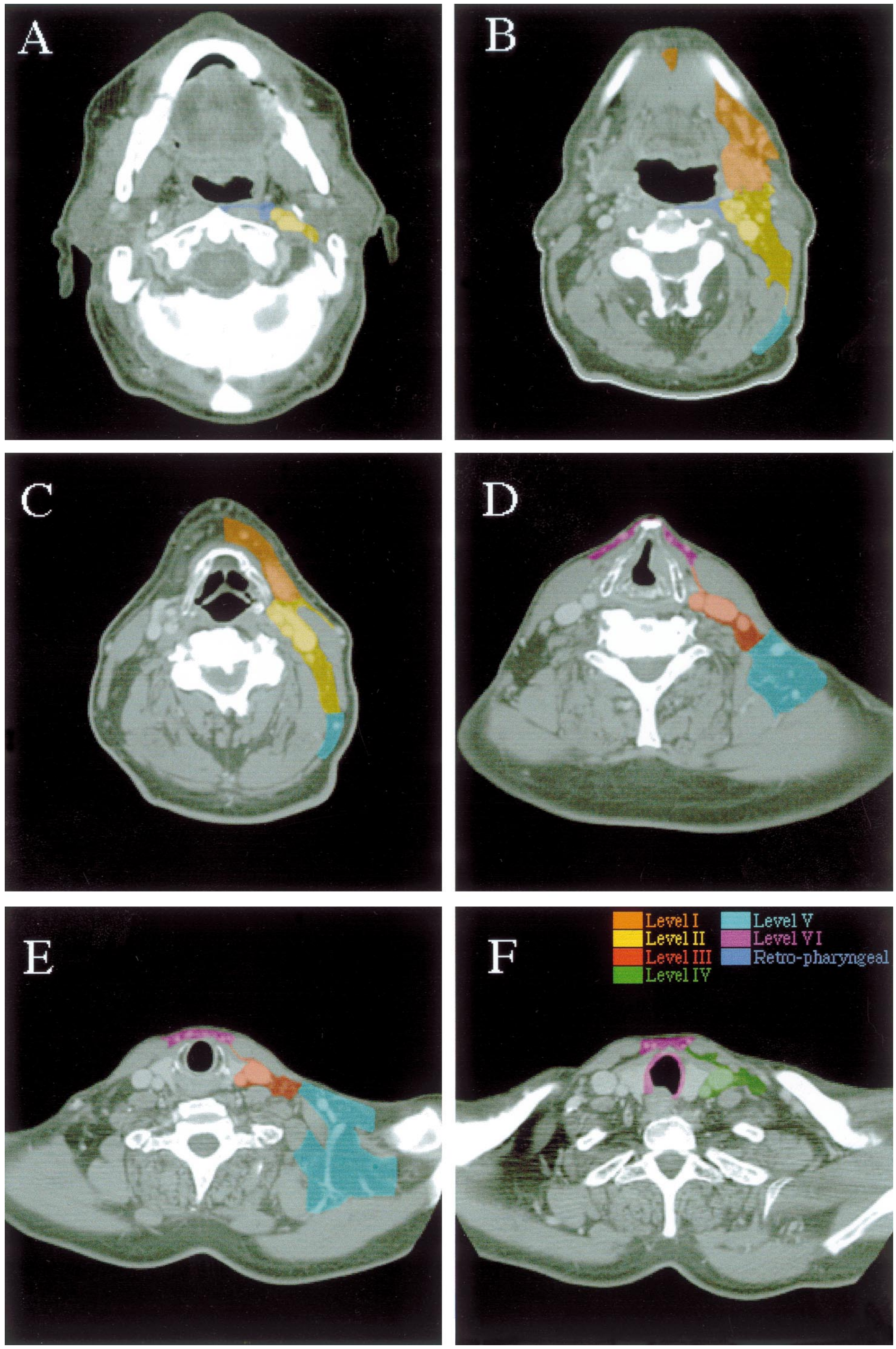

Fig. 1. CT imaging of a patient with a T1N0M0 glottic squamous cell carcinoma (see tumor in panel D). The examination was performed on a dual-detectors spiral CT (Elscint Twin, Haifa, Israel) using a slice thickness of 2.7 mm, an interval reconstruction of 2 mm and a pitch of 0.7. Contrast medium was injected intravenously at a rate of 2 ml/s with a total amount of 100 ml. Sections were taken at the level of the bottom edge of C1 (A), the upper edge of C3 (B), the mid C4 (C), the bottom edge of C6 (D), the bottom edge of C7 (E), and the mid D1 (F). Neck node levels were drawn on each CT slices using the radiological boundaries detailed in Table 10. Each node level corresponds to the CTV and thus do not include security margin for organ motion or setup inaccuracy.

Regarding the delineation of the upper limit of level II and their relationship with retropharyngeal nodes, a neck dissection of the upper jugular node typically never extends beyond the posterior belly of digastric muscle or the inferior edge of the parotid gland. On CT or MRI, as the visualization of the posterior belly of the digastric muscle is not always easy, the bottom edge of the body of C1 is recommended to draw the upper limit of level II. This upper limit is slightly more cranial compared with the surgical limit and thus includes more lymphatic tissue around the internal jugular vein and

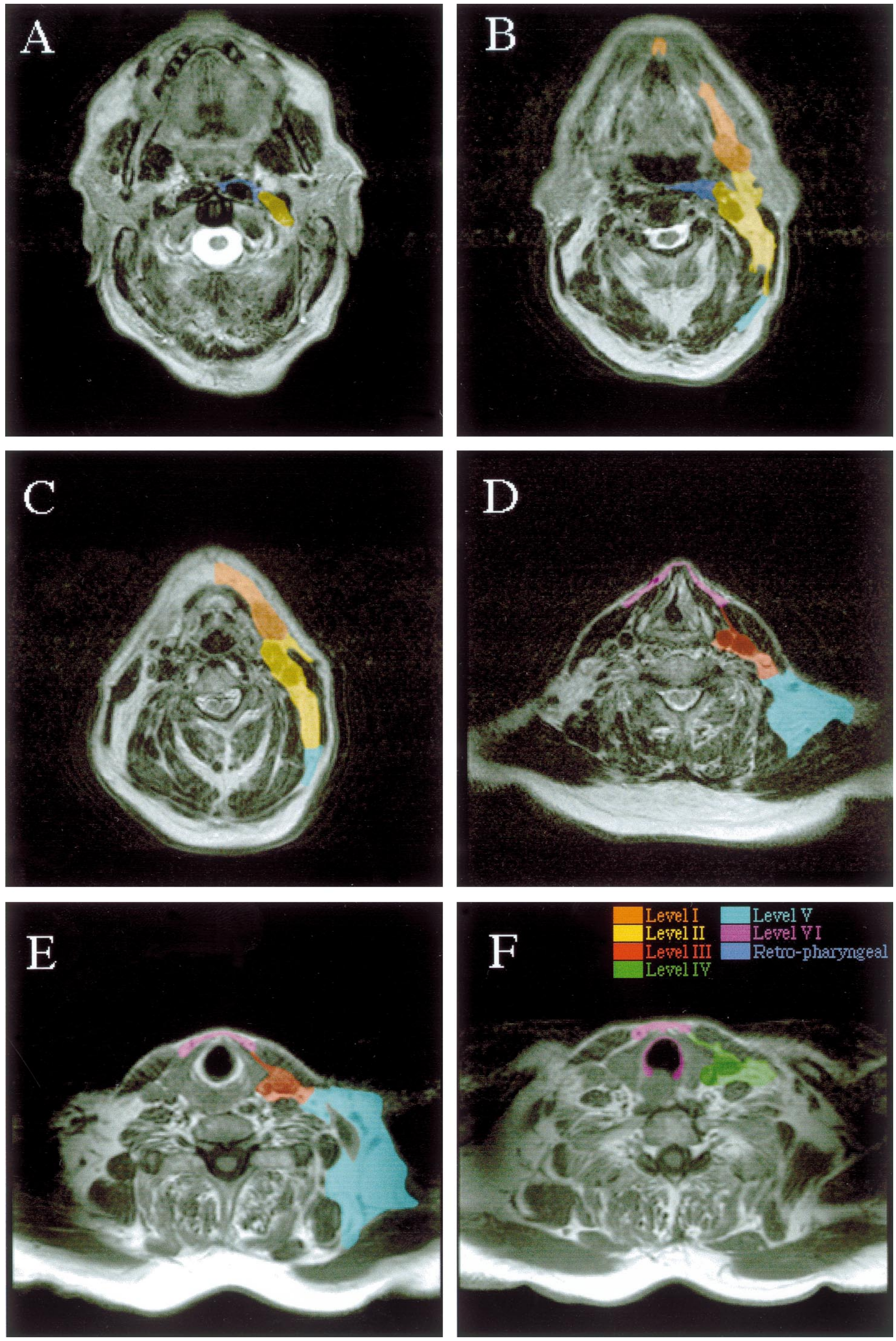

Fig. 2. MR imaging of the same patient with a T1N0M0 glottic squamous cell carcinoma (see tumor in panel D). The examination was performed on a Gyroscan NT 1.5 T Philips Medical systems (Eindhoven, The Nederlands) on an axial plane, with a slice thickness of 4 mm, a gap of 2 mm, and a field of view of 240 mm. T2-Weighted images (TR 7976 ms and TE 90 ms) are displayed in A–D. E–F represent T1-weighted images (TR 500 and TE 12 ms). Sections were taken at the level of the bottom edge of C1 (A), the upper edge of C3 (B), the mid C4 (C), the bottom edge of C6 (D), the bottom edge of C7 (E), and the mid D1 (F). Neck node levels were drawn on each slices using the radiological boundaries detailed in Table 10. The slight difference in the shape of the various levels between Figs. 1 and 2 is explained by a difference in the positioning of the patient leading to a slight difference in the slice levels. Each node level corresponds to the CTV and thus do not include security margin for organ motion or setup inaccuracy.

internal carotid artery. Retropharyngeal nodes extend medially to the internal carotid arteries (and thus medially to the level II nodes) from the base of the skull to the upper level of the hypopharynx which is delineated by an axial plane crossing the cranial edge of the hyoid bone. From there, the retropharyngeal nodes drain into the level II nodes.

The caudal limit of levels IV and V should include the transverse cervical nodal chain, which lies along the transverse cervical artery and vein and runs parallel to the clavicle. This nodal chain connects the dorsal cervical nodes to the caudal jugular nodes and drains near the junction between the internal jugular vein and the subclavian vein. Although never visualized on a single axial section, the cranial border of the clavicle should be taken as the lower limit of levels IV and V. It needs to be identified on several slices from the lateral portion of the clavicle to its medial portion. To limit the inherent variability in delineating the lower limit of levels IV and V, immobilization of patient on the table coach with a proper fixation device aiming at lowering the shoulders as much as possible is recommended. For the division between levels Va and Vb, the use of the limit between levels III and IV extended posteriorly is recommended.

Regarding the division between levels IIa and IIb, the spinal accessory nerve, which is not easily identified on CT or MRI, cannot be used. Som et al. proposed the use of the posterior edge of the internal jugular vein [54].

6. Conclusions

The increasing use of 3D treatment planning in head and neck radiation oncology has created an urgent need for new guidelines for the selection and delineation of the neck node areas to be included in the CTV. Surgical literature has provided us with valuable information on the extent of pathological nodal involvement in the neck as a function of the primary tumor site. In addition, a few clinical series have also reported information on radiological nodal involvement in those areas not commonly included in radical neck dissection. Taking all these data together, guidelines for the selection of the node levels to be irradiated for the major head and neck sites could be proposed. To fill the missing link between these guidelines and the 3D treatment planning, recommendations for the delineation of these node levels on CT (or MRI) slices have been proposed using the guidelines outlined by the Committee for Head and Neck Surgery and Oncology of the American Academy for Otolaryngology – Head and Neck Surgery. These guidelines, however, were adapted to take into account specific radiological landmarks more easily identified on CT or MRI slices than in the operating field.

Implementation of these guidelines in the daily practice of radiation oncology should contribute to a reduction in treatment variations from patients to patient and help in conducting multi-institutional clinical trials or retrospective studies. However, although guidelines are meant to be applied to the vast majority of patients, there will always be individual cases for whom sound clinical data preclude their use. More than ever, oncologic knowledge and wisdom are requested for appropriate use of the recommendations proposed here.

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