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Zbären, Peter; Becker, Minerva; Läng, Hubert

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Clinical Findings, Computed Tomography, and Magnetic Resonance Imaging Compared with Histopathology

Peter Zbären, M.D.[1]
Minerva Becker, M.D.[2]
Hubert Läng, M.D.[3]

[1] Department of Otorhinolaryngology and Head and Neck Surgery, University of Bern, Inselspital, Bern, Switzerland.

[2] Department of Diagnostic Radiology, University of Bern, Inselspital, Bern, Switzerland.

[3] Department of Pathology, University of Bern, Inselspital, Bern, Switzerland.

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Address for reprints: Dr. P. Zbären, Otolaryngology, Head and Neck Surgery, Inselspital, CH-3000 Bern, Switzerland.

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BACKGROUND. An accurate pretherapeutic staging of laryngeal carcinoma is required for most treatment planning as well as for evaluation and comparison of the results of different treatment modalities. Neoplastic invasion of the laryngeal cartilage may have important therapeutic implications. To our knowledge, no data are available comparing the impact of endoscopic examination, computed tomography (CT), and magnetic resonance (MR) imaging on pretherapeutic staging accuracy. The purpose of our study was to determine which imaging should be used as an adjunct to other clinical examinations in the pretherapeutic staging of laryngeal carcinoma.

METHODS. In this study, 40 consecutive patients with neoplasms of the larynx, who were treated surgically, were included in a prospective pretherapeutic staging protocol that included indirect laryngoscopy, direct microlaryngoscopy, contrast-enhanced CT, and gadolinium-diethylenetriamine pentaacetic acid-enhanced MR imaging at 1.5 Tesla. The surgical specimens were cut in whole-organ slices parallel to the plane of the axial CT and MR images. The histologic findings were compared with the clinical findings including the CT and MR images. The impact of each diagnostic method on pretherapeutic staging was analyzed.

RESULTS. Clinical/endoscopic evaluation failed to correctly stage 17 tumors due to invasion of the paraglottic space (1 tumor), preepiglottic space (2 tumors), and extralaryngeal soft tissues (14 tumors), resulting in a pretherapeutic staging accuracy of 57.5%. Neoplastic invasion of cartilage was present in 28 patients and absent in 12 patients. Although MR imaging was more sensitive in detecting neoplastic invasion of cartilage than CT (94% vs. 67%; $P = 0.001$), MR imaging was less specific than CT (74% vs. 87%; $P = 0.007$). There was no difference between the overall accuracy of CT and MR imaging in detecting neoplastic invasion of cartilage (80% vs. 82%). The accuracy of combined clinical/endoscopic examination and CT staging was 80% and the accuracy of combined clinical/endoscopic examination and MR imaging staging was 87.5%; the difference was not statistically significant.

CONCLUSIONS. Clinical/endoscopic examination alone failed to identify tumor invasion of the laryngeal cartilages and of the extralaryngeal soft tissues, resulting in a low staging accuracy (57.5%). Many pT4 (according to the International Union against Cancer TNM Staging System) tumors were clinically unrecognized. The combination of clinical/endoscopic evaluation and an additional radiologic examination, either CT or MR imaging, resulted in significantly improved staging accuracy (80% vs. 87.5%). MR imaging is significantly more sensitive but less specific than CT in detecting neoplastic cartilage invasion. Therefore, MR imaging tends to overestimate neoplastic cartilage invasion and may result in overtreatment, whereas CT tends to underestimate neoplastic cartilage invasion and may lead to inadequate therapy. ***Cancer* 1996; 77:1263–73.**

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KEYWORDS: laryngeal neoplasms, larynx tumor staging, larynx endoscopy, larynx MR imaging, larynx CT, larynx whole organ sections.

The most important factor in treatment planning of laryngeal carcinoma is the accuracy of pretherapeutic staging. The limitation of clinical and endoscopic tumor evaluation to assess the exact tumor extension of laryngeal carcinomas is well recognized.[1,2] The subglottic region and the anterior commissure may be hidden by bulky tumors. Deep tumor extension, such as infiltration of paraglottic and preepiglottic spaces, cartilaginous skeleton, and extralaryngeal structures, cannot be evaluated by endoscopy.

Laryngeal tomography, contrast laryngography, and xeroradiography have all been used for radiologically evaluating the tumor extent. Each of these methods proved unreliable in assessing deep tumor spread and cartilage invasion.[3] Since 1976, computed tomography (CT) has become a reliable technique for evaluating most tumors of the head and neck region.[4] It became the most important radiologic adjunct in the pretherapeutic staging of laryngopharyngeal cancer.[5-8] Nevertheless, CT scanning of the larynx has its limitations, especially in determining cartilage invasion,[9-14] due to the irregular mix of calcified, ossified, and noncalcified cartilage. However, neoplastic invasion of the laryngeal cartilage may have major therapeutic implications. Cartilage involvement reduces the chances of radiotherapy being successful and may also preclude voice preserving surgery, making total laryngectomy mandatory.[15,16]

Recently, magnetic resonance (MR) imaging has proved to be a reliable diagnostic method for the evaluation of laryngeal carcinoma. Based on the literature, MR imaging appears to be more suitable than CT in predicting neoplastic cartilage invasion.[14,17-19]

To date, it has not yet been determined which imaging modality, CT or MR imaging, should be used in the pretherapeutic staging of laryngeal carcinoma. To our knowledge, no data are available comparing the impact of clinical/endoscopic examination, CT, and MR imaging on the pretherapeutic staging, and few data are available comparing the results of CT and MR imaging with histology.[12,14,20]

The purpose of the present study was to assess the accuracy of the preoperative CT, MR imaging, and clinical/endoscopic staging by comparing the clinical and imaging findings of each modality with histologic cross-sections of the surgical specimens and to analyze the impact of these diagnostic modalities on pretherapeutic staging of laryngeal carcinoma.

MATERIALS AND METHODS

Patients

Between October 1992 and March 1995, 40 consecutive patients with neoplasms of the larynx, who were treated surgically, were included in a prospective pretherapeutic staging protocol including indirect laryngoscopy, direct microlaryngoscopy, contrast-enhanced CT, and gadolinium-diethylenetriamine pentacetic acid (Gd-DTPA)-enhanced MR imaging at 1.5 Tesla.

There were 39 males and 1 female with a mean age of 62 years (range, 44–87 years). Thirty-eight patients had squamous cell carcinoma, 1 patient had an undifferentiated nasopharyngeal carcinoma, and 1 patient had an adenocarcinoma. There were 6 supraglottic, 5 glottosupraglottic, 14 glottosubglottic, and 15 transglottic tumors. Thirty-six patients underwent total laryngectomy and 4 patients underwent voice preserving laryngectomy (supraglottic laryngectomy [n = 3] and subtotal laryngectomy [n = 1]).

Clinical and Endoscopic Evaluation

All patients underwent indirect laryngoscopy. If the larynx mobility could not be evaluated reliably, an additional transnasal fiberoptic laryngoscopy was performed. Thereafter, a panendoscopy with microlaryngoscopy and photographic documentation was performed in all patients.

CT and MR Imaging Techniques

CT was performed with a Somatom Plus Scanner (Siemens, Erlangen, Germany). Axial slices of 2-mm thickness and 2-mm interspace were obtained from the base of the tongue to the trachea after intravenous administration of 150 mL ioxithalamate-meglumine (Telebrix®, Guerbet, Aulnay-s.Bois, France). Additional scans were obtained during phonation and Valsalva manueuvers.

MR imaging was done on a Signa 1.5 T Performance Plus unit (GE Medical Systems, Milwaukee, WI) with an anterior neck coil. The MR imaging protocol consisted of an axial proton-density fast spin echo, T2-weighted fast spin echo and T1-weighted spin echo images. After intravenous administration of Gd-DTPA (Magnevist®, Schering, Germany), axial, sagital, and coronal T1-weighted spin echo images were obtained. The slice thickness was 3 mm or 4 mm (in large tumors) with a 0.3-, 0.4- or 1-mm intersection gap.

The CT and MR images were performed within a maximum interval of 2 weeks in each patient and reviewed separately by three independent radiologists in a blinded prospective fashion. The laryngectomy was performed 1–2 weeks after the last imaging study.

Histologic Workup

All surgical specimens underwent fixation in 4% formaldehyde for 72 hours and decalcification in De-cal Histological Decalcifying Agent (Pational Diagnostic, Mainville, NJ) for 2 weeks. Axial whole-organ slices were cut at a thickness of 3–5 mm parallel to the plane of the axial CT and MR images as described by Michaels and Gregor.[21] In selected cases, additional axial slices were cut at a

thickness of 1 mm. At each level, at least one slice was processed for microscopic examination, and hematoxylin and eosin staining was performed routinely. The histologic findings of each histologic specimen were compared with the CT and MR images at the respective levels.

Classification of Primary Tumors

The lesions were staged for tumor (T) according to the International Union against Cancer, TNM classification 1992 and TNM Supplement 1993.[22,23] Invasion of tissue beyond the larynx (e.g., on the outer side of thyroid or cricoid cartilage or soft tissues of the neck) was classified as T4, whereas neoplastic cartilage infiltration with intact outer perichondrium was classified as T3. Tumors with extension to the paraglottic space were radiologically and pathologically staged as T3.[2,24,25] Neoplastic infiltration of the arytenoid did not influence the T-classification.

Statistical Analysis

Statistical comparison of the results was performed by using the two-tailed Fisher's exact test for matched pairs for a small sample size based on binomial distribution according to Agresti.[26]

RESULTS

Histopathologic Analysis and pT Staging

The anterior commissure was invaded in 29 of 37 specimens, and the subglottic region in 29 of 37 specimens. In two cases, the tumor involvement of the anterior commissure was entirely submucosal as was the tumor involvement in the subglottis in one case. Tumor involvement of the preepiglottic space was observed in 9 of 40 specimens and of the paraglottic space in 31 of 37 specimens. Neoplastic invasion of cartilages was present in 28 of 40 specimens (thyroid cartilage [n = 17], cricoid cartilage [n = 16], and arytenoid cartilage [n = 22]). With regard to pathologic assessment, 5 tumors were classified as pT2, 19 as pT3, and 16 as pT4.

Clinical/Endoscopic Findings and Clinical/Endoscopic Staging

Based on indirect or fiberoptic laryngoscopy, vocal cord mobility was diminished or absent in 30 patients. In 28 patients, vocal cord fixation corresponded at histopathology to tumor invasion of the paraglottic space and in 2 patients to invasion of the ventricular fold and the arytenoid cartilage.

On microlaryngoscopy, the anterior commissure was invaded in 26 out of 40 cases, and the subglottic region was invaded in 25 cases. Anterior commissure and subglottic involvement was missed at endoscopy in 3 and 4 cases, respectively. In 4 of these 7 cases, the anterior commissure and subglottic region were hidden behind a bulky tumor mass, which in one case was essentially submucosal, and only deep biopsies obtained during microlaryngoscopy allowed definitive diagnosis (Fig. 1). In the 3 other cases, tumor extension was essentially submucosal (Fig. 2).

According to the clinical and microlaryngoscopic examination, 10 laryngeal tumors were classified as T2, 28 as T3, and 2 as T4. Seventeen of 40 cases were staged incorrectly: 12 pT4 tumors were clinically classified as T3, 2 pT4 tumors were classified as T2, and 3 pT3 tumors were classified as T2. All cases were understaged. The accuracy of clinical staging was 23 of 40 cases (57.5%). Clinical evaluation failed to correctly classify 1 tumor with invasion of the paraglottic space, 2 tumors with invasion of the preepiglottic space, and 14 tumors with neoplastic invasion of tissues out of the larynx (tumor growths through cartilage [n = 10], through the cricothyroid membrane, [n = 99]).

Findings and Staging by CT and MR Imaging

The results are summarized in Table 1 and 2.

According to the CT findings, 6 laryngeal tumors were classified as T2, 22 as T3, and 12 as T4. Eight of 40 cases were staged incorrectly: 5 pT4 tumors were classified by CT as T3, 1 pT4 tumor as T2, and 2 pT3 tumors as T4. Thus, six cases were understaged and two were overstaged.

According to combined clinical and CT evaluation, 6 laryngeal tumors were classified as T2, 22 tumors as T3, and 12 tumors as T4, taking the higher stage of the 2 staging modalities into account. The results of histopathologic, clinical, combined clinical, and CT, and combined clinical and MR imaging staging are summarized in Table 3.

According to the MR imaging findings, 4 laryngeal tumors were classified as T2, 17 tumors as T3, and 19 tumors as T4. Five of 40 cases were staged incorrectly: 3 pT3 tumors were classified by MR imaging as T4, 1 pT2 tumor as T4, and 1 pT4 tumor as T3. Thus, four cases were overstaged and one case was understaged.

According to combined clinical and MR imaging evaluation, 4 laryngeal tumors were classified as T2, 17 as T3, and 19 as T4, taking the higher stage of the 2 staging modalities into account. The results of histopathologic, clinical, combined clinical and CT, and combined clinical and MR imaging staging are summarized in Table 3.

For the assessment of the anterior commissure, the subglottic region, and the preepiglottic and the paraglottic space, there were no significant differences between CT and MR imaging (Table 1 and 2, Figs. 3 and 4). With regard to assessment of cartilage neoplastic invasion, MR imaging has a significantly higher sensitivity than CT ($P = 0.001$), whereas CT has a significantly higher specificity than MR imaging ($P = 0.007$). There was no statistical

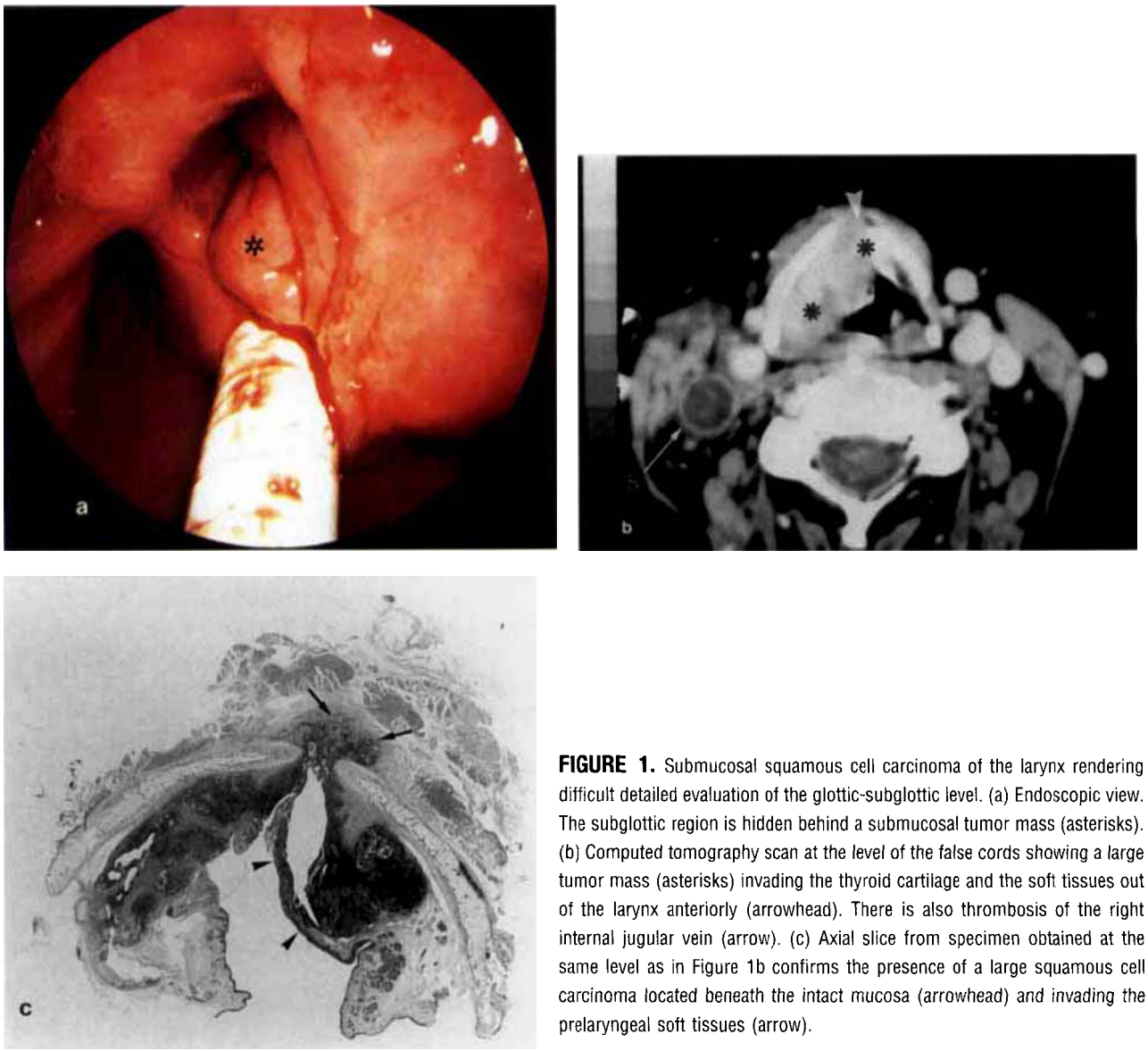

FIGURE 1. Submucosal squamous cell carcinoma of the larynx rendering difficult detailed evaluation of the glottic-subglottic level. (a) Endoscopic view. The subglottic region is hidden behind a submucosal tumor mass (asterisks). (b) Computed tomography scan at the level of the false cords showing a large tumor mass (asterisks) invading the thyroid cartilage and the soft tissues out of the larynx anteriorly (arrowhead). There is also thrombosis of the right internal jugular vein (arrow). (c) Axial slice from specimen obtained at the same level as in Figure 1b confirms the presence of a large squamous cell carcinoma located beneath the intact mucosa (arrowhead) and invading the prelaryngeal soft tissues (arrow).

difference between the accuracy of CT and MR imaging in detecting cartilage invasion (Table 1 and 2).

The accuracy of clinical/endoscopic staging was 55%. The accuracy of combined clinical and CT staging was 80%, and the accuracy of combined clinical and MR imaging staging was 87.5%. Both imaging modalities combined with clinical/endoscopic evaluation having a significantly higher accuracy than clinical/endoscopic staging alone (clinical vs. clinical and CT staging: $P = 0.004$; clinical vs. clinical and MR imaging staging: $P = 0.001$). Between combined clinical and CT staging and combined clinical and MR imaging stating, there was no statistical difference (Table 4).

DISCUSSION

An accurate pretherapeutic staging is required for optimal treatment planning and, moreover, for evaluation and comparison of the results of different treatment modalities. The endoscopic examination allows accurate evaluation of superficial tumor extension. Specific sites, such as the anterior commissure, laryngeal ventricle, and the subglottic region, are often difficult to examine in the presence of an adjacent exophytic tumor. In addition, there are areas, such as the paraglottic space, the preepiglottic space, and the laryngeal framework (all important structures for treatment planning), that cannot be evaluated endoscopically.

Clinical and Endoscopic Staging

Clinical/endoscopic staging alone fails to correctly estimate the true extension of the tumor in a high percentage of cases.[1,2] In the present study, we observed inaccurate clinical/endoscopic staging in 17 (45%) of 40 laryngeal

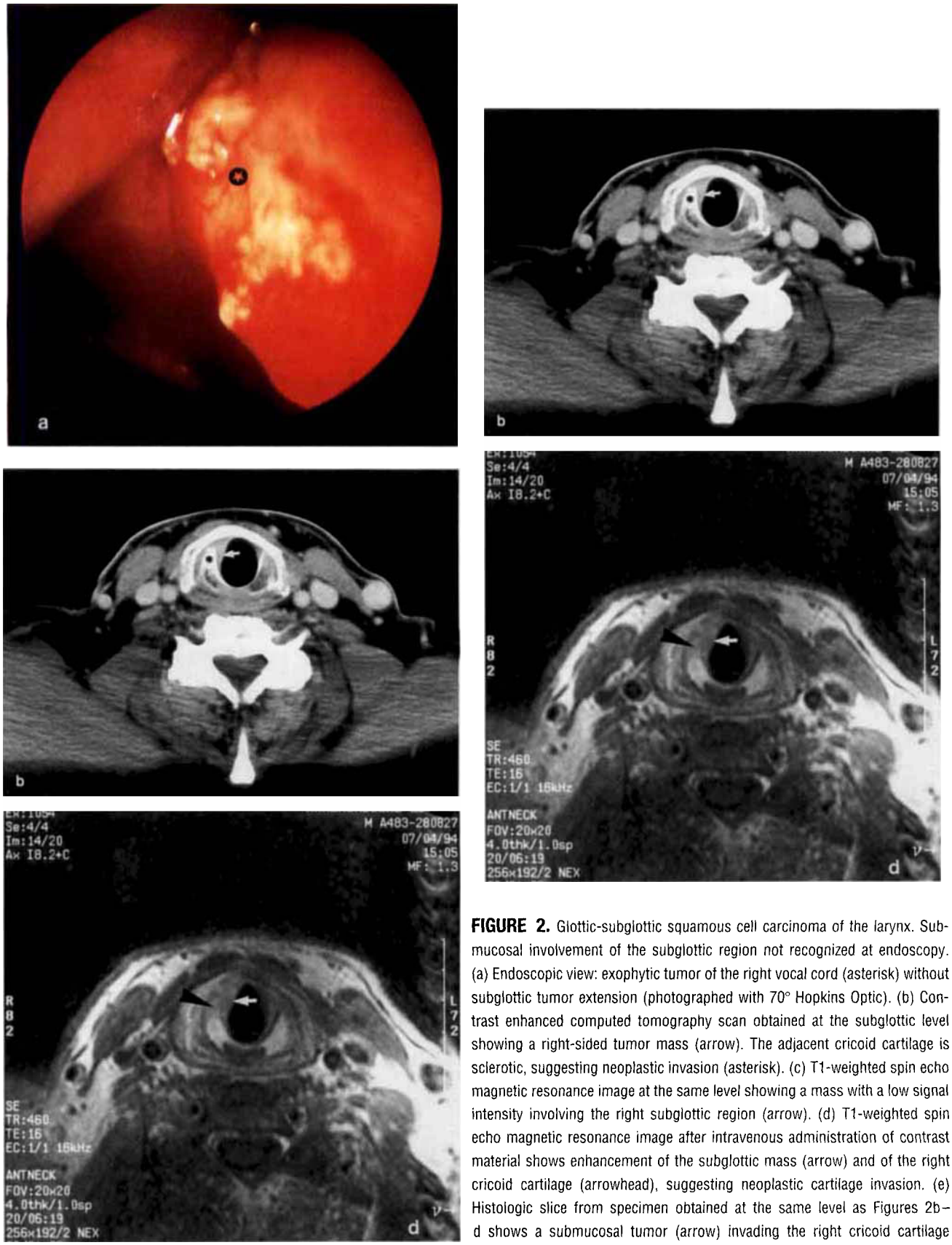

FIGURE 2. Glottic-subglottic squamous cell carcinoma of the larynx. Submucosal involvement of the subglottic region not recognized at endoscopy. (a) Endoscopic view: exophytic tumor of the right vocal cord (asterisk) without subglottic tumor extension (photographed with 70° Hopkins Optic). (b) Contrast enhanced computed tomography scan obtained at the subglottic level showing a right-sided tumor mass (arrow). The adjacent cricoid cartilage is sclerotic, suggesting neoplastic invasion (asterisk). (c) T1-weighted spin echo magnetic resonance image at the same level showing a mass with a low signal intensity involving the right subglottic region (arrow). (d) T1-weighted spin echo magnetic resonance image after intravenous administration of contrast material shows enhancement of the subglottic mass (arrow) and of the right cricoid cartilage (arrowhead), suggesting neoplastic cartilage invasion. (e) Histologic slice from specimen obtained at the same level as Figures 2b–d shows a submucosal tumor (arrow) invading the right cricoid cartilage (arrowhead).

TABLE 1
Findings at Computed Tomography

	No.	True-positive	True-negative	False-positive	False-negative	Accuracy %
Anterior commissure	37	29	2	6	0	83
Subglottic region	37	27	5	3	2	86
Paraglottic space	37	29	3	3	2	86
Preepiglottic space	40	9	29	2	0	95
Cartilages	148	37	81	12	18	80

There were 36 total laryngectomy specimens, 3 supraglottic and 1 subtotal laryngectomy specimen

TABLE 2
Findings at Magnetic Resonance

	No.	True-positive	True-negative	False-positive	False-negative	Accuracy %
Anterior commissure	37	29	2	6	0	83
Subglottic region	37	28	5	3	1	89
Paraglottic space	37	30	3	3	1	89
Preepiglottic space	40	9	28	3	0	92.5
Cartilages	148	52	69	24	3	82

There were 36 total laryngectomy specimens, 3 supraglottic, and 1 subtotal laryngectomy specimen.

TABLE 3
Comparison of T-Staging of Different Diagnostic Modalities

	Pathologic staging	Clinical staging	CT staging	MR imaging staging	Combined clinical and CT staging	Combined clinical and MR imaging staging
T2	5	10	6	4	6	4
T3	19	28	22	17	22	17
T4	16	2	12	19	12	19

CT: computed tomography; MR: magnetic resonance.

tumors. These findings are quite similar to those reported by Pillsbury and Kirchner,[1] who observed a rate of 40% of clinical staging errors or by Sulfaro et al.,[2] who indicated 41% clinical staging errors for laryngeal neoplasms.

The anterior commissure and the subglottic region are often hidden by bulky tumors (Fig. 1). The oncolgic importance of the anterior commissure has been emphasized by many authors.[27,28] It is the preferential pathway for cancer extension to the anterior angle of the thyroid cartilage and downward to the subcommissural region and cricothyroid membrane. In our study, anterior commissure invasion was missed by endoscopy in three cases. In these three cases, the anterior commissure involvement was diagnosed by CT and MR imaging.

Tumor extension to the subglottic region is a contraindication for voice-preserving surgery. Therefore, a correct pretherapeutic evaluation of the subglottis is mandatory for optimal treatment planning. In the present study, subglottic tumor extension was missed during endoscopy in four cases (Fig. 2). CT evaluation was correct in two cases and MR imaging evaluation in three of these four cases.

All clinical/endoscopic staging errors consisted of an underestimation that resulted from a failure to clinically identify invasion of the paraglottic and preepiglottic space and destruction of laryngeal cartilage with extralaryngeal tumor invasion. Therefore, many pT4 laryngeal tumors were clinically unrecognized (Table 3). Detection

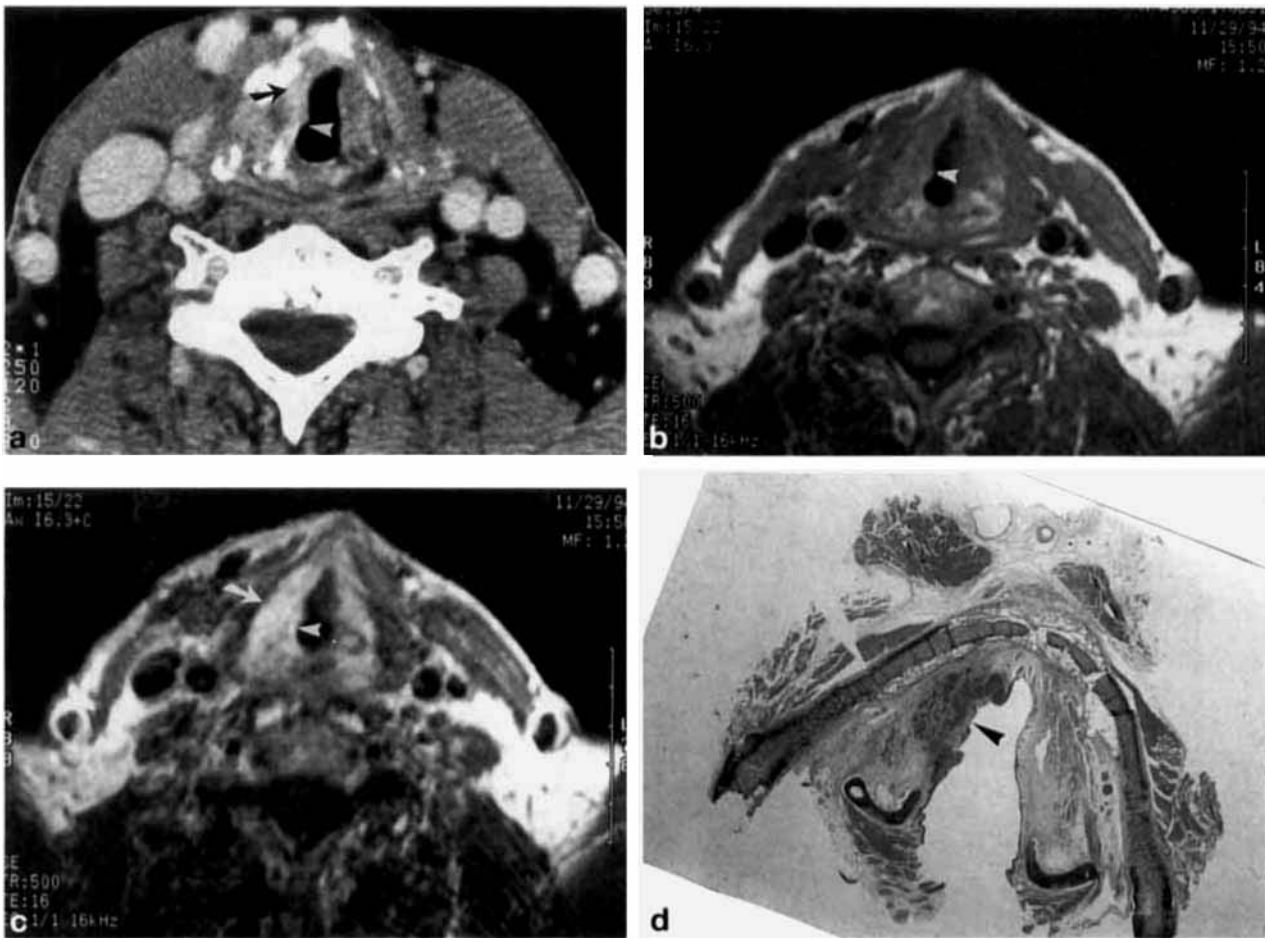

FIGURE 3. Glottic-supraglottic squamous cell carcinoma of the larynx with infiltration of the paraglottic space. (a) Contrast-enhanced computed tomography scan at the level of the vocal cords showing a right-sided slightly exophytic lesion (arrowhead) extending to the inner border of the right thyroid cartilage. There is suspicion of paraglottic space invasion (arrow). (b) T1-weighted spin echo magnetic resonance image at the same level shows a slightly hypodense lesion of the right vocal cord (arrowhead). (c) T1-weighted spin echo magnetic resonance image after intravenous administration of contrast material showing an important enhancement of the tumor mass (arrowhead) as well as invasion of the right paraglottic space (arrow). There is no enhancement of the right thyroid cartilage, suggesting that there is no tumor invasion of the cartilage. (d) Histologic slice at the same level confirms tumor invasion of the right paraglottic space (arrowhead). There is no invasion of the thyroid cartilage.

of cartilage invasion is not only an important factor for accurate staging but also for optimal treatment planning in laryngeal carcinoma. Its presence precludes laryngeal conservation surgery in many cases and is associated with an increased risk of perichondritis, necrosis, and edema following radiation therapy. Therefore, many authors assume that radiotherapy is not an appropriate treatment for laryngeal carcinomas with neoplastic cartilage invasion.[29–31]

CT and MR Imaging Evaluation and Staging

The CT assessment of the paraglottic space was correct in 86% of cases, and the MR imaging assessment in 89% of cases. There was no statistically significant difference between CT and MR imaging. Tumors arising in the ventricle first invade the paraglottic space and then both the supraglottic and subglottic areas without being recognizable by endoscopic examination.[32] Because both CT and MR imaging were performed using thin slices (2 and 3 mm), paraglottic and subglottic tumor spread was well detected on axial images. Coronal MR imaging was excellent in depicting craniocaudal tumor spread; however, this did not reveal any findings that were not detected on axial imaging.

The CT assessment of the preepiglottic space was correct in our study in 95% of cases and the MR imaging assessment in 92.5% of cases. There was no statistical difference between CT and MR imaging. The results of CT assessment of the paraglottic and preepiglottic space are slightly better than those in the literature.[20,33,34] This

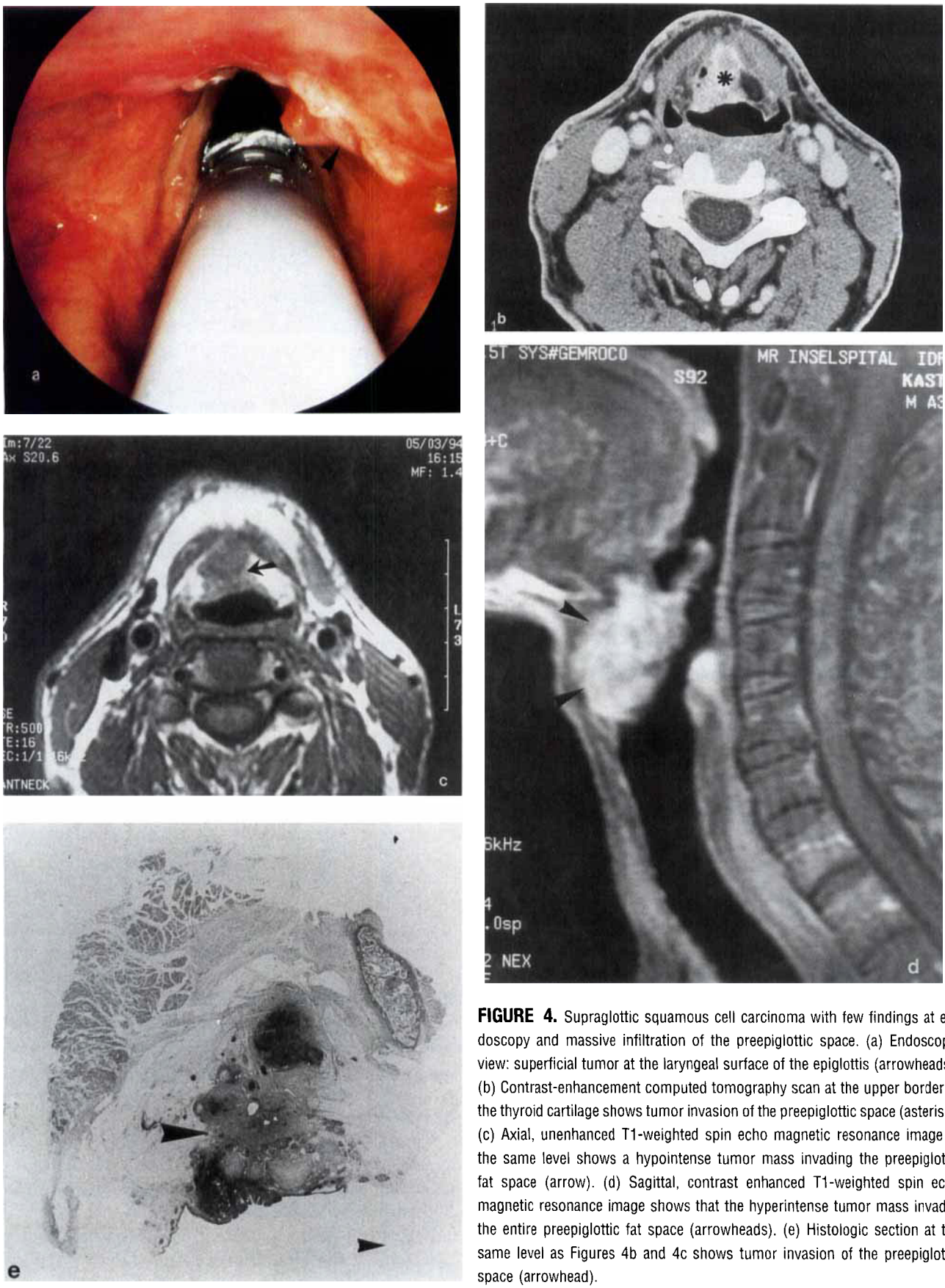

FIGURE 4. Supraglottic squamous cell carcinoma with few findings at endoscopy and massive infiltration of the preepiglottic space. (a) Endoscopic view: superficial tumor at the laryngeal surface of the epiglottis (arrowheads). (b) Contrast-enhancement computed tomography scan at the upper border of the thyroid cartilage shows tumor invasion of the preepiglottic space (asterisk). (c) Axial, unenhanced T1-weighted spin echo magnetic resonance image at the same level shows a hypointense tumor mass invading the preepiglottic fat space (arrow). (d) Sagittal, contrast enhanced T1-weighted spin echo magnetic resonance image shows that the hyperintense tumor mass invades the entire preepiglottic fat space (arrowheads). (e) Histologic section at the same level as Figures 4b and 4c shows tumor invasion of the preepiglottic space (arrowhead).

TABLE 4
Accuracy of Different Diagnostic Modalities for T-Staging

	Accuracy
Clinical T-staging	23/40 (57.5%)
CT T-staging	32/40 (80%)
MR imaging T-staging	35/40 (87.5%)
Combined clinical and CT T-staging	32/40 (80%)
Combined clinical and MR imaging T-staging	35/40 (87.5%)

CT: computed tomography; MR: magnetic resonance.

is probably due to the imaging technique (thin slices). The correct assessment of the preepiglottic space is particularly important when a supraglottic laryngectomy or a cricohyoidopexy are considered. In addition, consideration of the preepiglottic space is mandatory for a correct tumor classification; supraglottic tumors progress into T3 tumors if the preepiglottic space is involved. For evaluation of the preepiglottic space, the MR imaging offers the possibility of sagittal planes (Fig. 4).

Preoperative determination of cartilage involvement is indispensable for treatment planning. Cricoid involvement generally results in total laryngectomy. Neoplastic involvement of the anterior part of the thyroid cartilage precludes any type of vertical partial laryngectomy.

According to the literature, CT accurately demonstrates gross cartilage invasion, especially in the presence of extralaryngeal tumor spread, but fails to detect minor cartilage invasion in many cases.[9,11,12,14,35] The ability of the CT to detect neoplastic invasion varies widely with reported sensitivities of 46–66% and specificities of 84–94%.[12,14] In the present study, we found a sensitivity of 67% and a specificity of 87%. The irregular calcification pattern of the thyroid cartilage does not correlate with tumor invasion nor can normal and pathologic cartilage be distinguished on the basis of density values.[9,11,13,35] In the cricoid and arytenoid cartilage, however, asymmetric irregular sclerosis (Figs. 2 and 3) could be used as an ancillary sign of cartilage invasion.[13,36] MR imaging shows details of nonossified and ossified cartilage better than CT.[12,14] The reported overall sensitivity of MR imaging in the detection of neoplastic cartilage invasion is 89% and the specificity varies between 82% and 88%.[12,14] In our study based on 40 cases, we found a sensitivity of 94% and a specificity of 74%. MR imaging had a significantly higher sensitivity to detect neoplastic cartilage invasion than CT, but had a significantly lower specificity. As recently reported, this is caused by severe inflammatory changes, fibrosis, and extramedullary hematopoiesis within the cartilage, which result in a higher rate of false-positive MR imaging assessments.[14] There was no statistical difference between the overall accuracy in detecting neoplastic cartilage invasion between CT and MR imaging. MR imaging tends to overestimate (high false-positive rate) neoplastic cartilage invasion and therefore may result in overtreatment to the extreme: a needless total laryngectomy. Therefore, the tendency of MR imaging to overestimate cartilage tumor invasion can represent a limitation of its use as an imaging technique. CT tends to underestimate (high false-negative rate) neoplastic cartilage invasion and therefore may lead to inadequate therapeutic decisions, i.e., inappropriate partial laryngectomy or primary radiotherapy with the risk of subsequent radiochondronecrosis. Knowledge of the potential pitfalls of both imaging techniques, namely underestimation of cartilage invasion with CT and overestimation with MR imaging, is essential in deciding on the appropriate therapy. A careful interdisciplinary interpretation of the CT and MR imaging findings with the head and neck surgeon, the radiologist, and the radiooncologist, taking in account the clinical and endoscopic findings, is mandatory in the avoidance of inappropriate treatment.

The usefulness of CT and MR imaging in the pretherapeutic staging of laryngeal carcinoma was emphasized in many studies.[4,5,7,8,13,15,17,24,37–39] Several studies compare CT data[2,7,10,11,35,40,41] and a few studies compare MR imaging data with the histology of whole-organ sections.[12,14,17,42] However, to our knowledge, no data are available comparing the results of endoscopic, CT, and MR imaging findings with anatomically matched histologic whole-organ sections analyzing the impact of each diagnostic method on the pretherapeutic staging.

In the present study, the accuracy of combined clinical and CT staging was 80% and the accuracy of combined clinical and MR imaging staging was 87.5%. The difference is not statistically significant. This is due to the equivalent overall accuracy in detecting neoplastic cartilage invasion of CT and MR imaging despite different sensitivities and specificities.

In summary, in the present study, we were unable to express a preference for one of both discussed imaging modalities, CT or MR imaging, for the pretherapeutic investigation of laryngeal carcinoma.

CONCLUSIONS

- Clinical/endoscopic evaluation fails to identify invasion of the laryngeal framework and of extralaryngeal soft tissues in a high percentage of cases; therefore many pT4 laryngeal tumors are clinically unrecognized.
- An additional radiologic examination, either CT or MR imaging, is essential in most laryngeal carcinomas for the correct pretherapeutic staging and proper treatment.
- In predicting tumor infiltration of the preepiglottic and paraglottic spaces, there is no statistically significant difference between CT and MR imaging.

- MR imaging is significantly more sensitive than CT in detecting neoplastic cartilage invasion. However, MR imaging tends to overestimate neoplastic cartilage invasion and therefore may result in overtreatment.
- CT is significantly more specific in detecting neoplastic cartilage invasion than MR imaging but tends to underestimate neoplastic cartilage invasion and therefore may lead to inadequate therapeutic decisions.
- The preoperative staging accuracy is improved by combining the information gained by both clinical and CT or clinical and MR imaging. The staging accuracy of combined clinical and MR imaging is higher but does not differ significantly from the staging accuracy of combined clinical and CT assessment.
- An interdisciplinary evaluation of all clinical, endoscopic, and radiologic findings by the radiologist, head and neck surgeon, and radiooncologist is mandatory in order to avoid inappropriate treatment.

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