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CT findings.**

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# Soft-Tissue Changes After Head and Neck Radiation: CT Findings

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To identify possible soft-tissue changes of the head and neck after radiation therapy, 102 CT scans from 78 patients with head and neck tumors were reviewed to assess (1) skin thickening, (2) epiglottic thickening, (3) stranding of subcutaneous fat, and (4) stranding of deep cervical fat. Scans were obtained after radiation therapy alone (10 cases), after radiation and surgery (27 cases), after surgery alone (24 cases), or before either surgery or radiation (41 cases). Skin thickening, epiglottic thickening, and stranding of subcutaneous fat were seen more frequently after radiation therapy than before such treatment. However, skin thickening and stranding of subcutaneous fat were sometimes also associated with tumor involvement and/or previous surgery, while epiglottic thickening was only occasionally associated with tumor involvement. Stranding of deep cervical fat was noted with increased frequency after radiation or surgery, but postradiation effects could not be reliably distinguished from postsurgical or tumor effects.

We conclude that soft-tissue changes of the head and neck on CT may commonly be associated with previous radiation therapy, but these postradiation effects are not always distinguishable from postsurgical effects or tumor.

CT is commonly performed on patients who have had radiation therapy for head and neck tumors. These CT scans frequently reveal a number of soft-tissue changes, including induration of the skin and subcutaneous fat [1, 2], epiglottic thickening [3, 4], and increased density of the salivary gland [2, 5, 6]. However, these changes have not been studied systematically or distinguished from other effects associated with surgery or tumor. This information may be important for determining whether certain CT findings are the result of previous radiation therapy.

To determine which soft-tissue changes on CT are associated with previous radiation therapy, we reviewed retrospectively 102 CT scans obtained in 78 patients with head and neck tumors.

## Materials and Methods

We reviewed retrospectively 102 CT scans obtained from 78 patients with tumors of the head and neck who were treated at a university hospital between January 1983 and May 1986. Scans were obtained after radiation therapy alone (10 cases), after radiation therapy and surgery (27 cases), after surgery alone (24 cases), or before either radiation or surgery (41 cases). Twenty-two patients had CT scans both before and after radiation.

CT scans were performed on a GE 8800 or 9800 system or a Picker 1200 system. In most cases, 5-mm contiguous axial scans from the base of the skull to the thoracic inlet were obtained during rapid injection of 150 ml of Conray 60. However, some scans were obtained without IV contrast, and occasional follow-up studies included only limited images directed at the site of original tumor. All scans were reviewed retrospectively by three radiologists without knowledge of the type of tumor or previous treatment, and each scan was assessed for (1) skin thickening; (2) epiglottic thickening; (3) stranding of subcutaneous fat in both suprahyoid and subhyoid regions; and (4) stranding of deep cervical fat in the parapharyngeal, preepiglottic, perilaryngeal, perivascular, and posterior cervical spaces.

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Skin thickening on CT images was measured by comparing hand-held caliper measurements to the centimeter scale on an image in which the skin was perpendicular to the plane of the scan. Skin thickening was recorded as either present (4 mm thick or greater) or absent. The epiglottic thickness on CT was measured at the cephalad aspect of the epiglottis in a similar manner. Soft-tissue density stranding of fat was graded as (a) mild stranding, (b) moderate to severe stranding, or (c) confluent obliteration of fat. The location of skin thickening or stranding of fat, if present, was also recorded. Each scan was also evaluated for the degree of IV contrast enhancement; postsurgical changes (absence or distortion of anatomic structures); and presence, location, and extent of tumor.

Subsequently, the patients' hospital and radiation oncology records were reviewed to evaluate the pathologic tumor type and location at physical examination/endoscopy, as well as the type, amount, and dates of treatment. The time between completion of radiation therapy and CT study averaged 30 weeks (range, 2–153 weeks) in those patients who were irradiated. The time between surgery and CT study was variable (range, 7 days to 11 years).

Soft-tissue changes were considered to result from radiation when (1) tumor and surgically absent/distorted anatomy were not seen in the immediate area on CT or (2) bilateral CT soft-tissue changes were present, separate from unilateral tumor/postsurgical effects, and (3) there was no clinical record of tumor or previous surgery in the location of CT abnormality.

Statistical analysis was performed with chi-square contingency tables to evaluate significance of the frequency of CT findings in the treatment groups and with Kruskal-Wallis and Mann-Whitney non-parametric methods to evaluate the significance of timing of CT after each mode of treatment.

## Results

The frequency of skin thickening among patient groups is shown in Table 1. Skin thickness of 4 mm or greater was present in 17 (46%) of 37 patients who had received radiation (Fig. 1); only five of these patients showed thickening in regions distant from tumor or surgery. The patients who had not received radiation did not demonstrate skin thickening in regions distant from tumor or surgery. Only two patients who were scanned before any treatment demonstrated focal skin thickening; one of these two patients demonstrated an adjacent abscess, and the other showed a calculus in the submandibular gland duct with associated sialadenitis. Nine (41%) of 22 patients who had scans both before and after radiation demonstrated interval skin thickening; four of these patients showed thickening in regions distant from tumor or surgery.

The frequency of epiglottic thickening among the patient groups is shown in Table 2. Epiglottic thickening greater than 4 mm was present in 10 (48%) of 21 patients after radiation (Fig. 2), after excluding four patients who proved to have clinical evidence of tumor involvement of the epiglottis. In comparison, this degree of epiglottic thickening was observed in none of the 19 patients who only had surgery ( $p < .01$ ) and in two (5%) of 37 patients who had no previous treatment ( $p < .001$ ), after excluding those patients with clinical evidence of epiglottic tumor.

The frequency of stranding of subcutaneous fat is shown in Table 3. Twenty-one (57%) of 37 patients scanned after radiation showed stranding of subcutaneous fat in the suprahyoid and/or subhyoid regions distant from tumor or surgery, compared with only six (25%) of 24 patients after surgery alone ( $p < .05$ ), and five (12%) of 41 patients scanned before treatment ( $p < .001$ ) (Fig. 3). Of those patients who had scans both before and after radiation, 10 (53%) of 19 developed stranding of subhyoid subcutaneous fat distant from tumor or surgery, and six (27%) of 22 developed stranding in the suprahyoid region. Nearly all patients who showed skin thickening also showed stranding of adjacent subcutaneous fat.

The frequency of stranding of fat in different regions of the head and neck for the patient groups is shown in Table 4. The frequency of stranding in deep cervical fat was higher in patients who had previous treatment compared with those who did not. However, the effects of radiation could not be reliably distinguished from postsurgical or tumor effects. This was true of all the deep cervical spaces analyzed, including the parapharyngeal, paralaryngeal, preepiglottic, and perivascular regions. However, fat in the posterior cervical space rarely showed stranding, and then only from adjacent tumor or abscess.

Other factors not significantly associated with soft-tissue changes on CT included the time between treatment and CT study, and the type or amount of radiation.

## Discussion

Evaluation of CT findings from patients with head and neck tumors must take into account multiple causative factors, including the presence and extent of tumor [7, 8], concurrent infection or inflammation [2, 8–10], postoperative effects [9–13], and postradiation changes. Attempting to distinguish between these causes may be difficult or impossible. Never-

**TABLE 1: Frequency of Skin Thickening Among Treatment Groups**

	Radiation and Surgery ( <i>n</i> = 27)	Radiation Only ( <i>n</i> = 10)	Surgery Only ( <i>n</i> = 24)	Before Treatment ( <i>n</i> = 41)
Abnormal skin thickness close to tumor or surgery	16 (59%)	1 (10%)	6 (25%)	2* (5%)
Abnormal skin thickness distant from tumor or surgery	5 (19%)	0	0	0

\* One patient with an abscess and one with submandibular gland duct stone and sialadenitis.



Fig. 1.—A, Focal skin thickening and mild stranding of subcutaneous fat (arrows) associated with surgery and/or radiation in a patient with right parotid pleomorphic adenoma after multiple partial parotidectomies, most recent 7 months earlier. A course of 2040 rad (20.4 Gy) of neutrons was completed 23 weeks before the scan.

B, Skin thickening (arrows) associated with surgery and/or radiation in a patient with left tonsillar squamous cell carcinoma 14 months after left radical neck dissection/composite resection, and 49 weeks after completion of combination photon/neutron radiation. Note loss of left pericarotid (A) fat planes associated with surgery and/or radiation, and abnormally dense right submandibular gland (S), greater density than muscle (M) and nearly isodense with carotid artery (A), most likely associated with previous radiation.

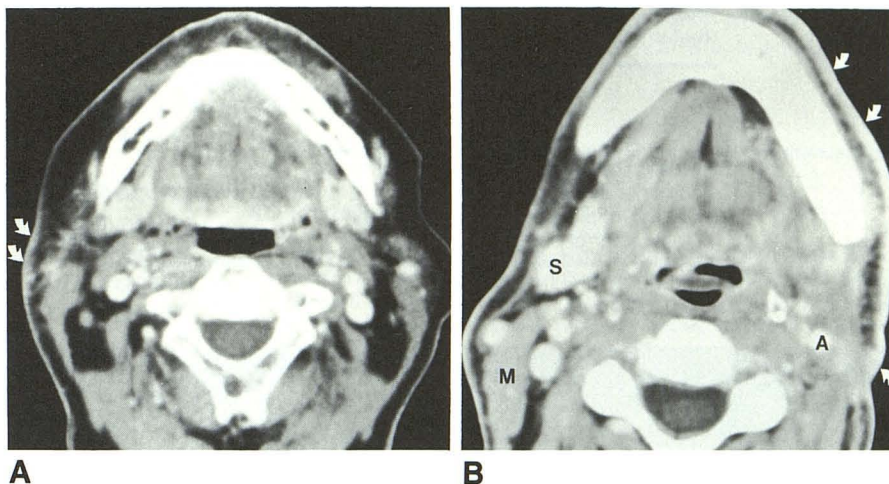
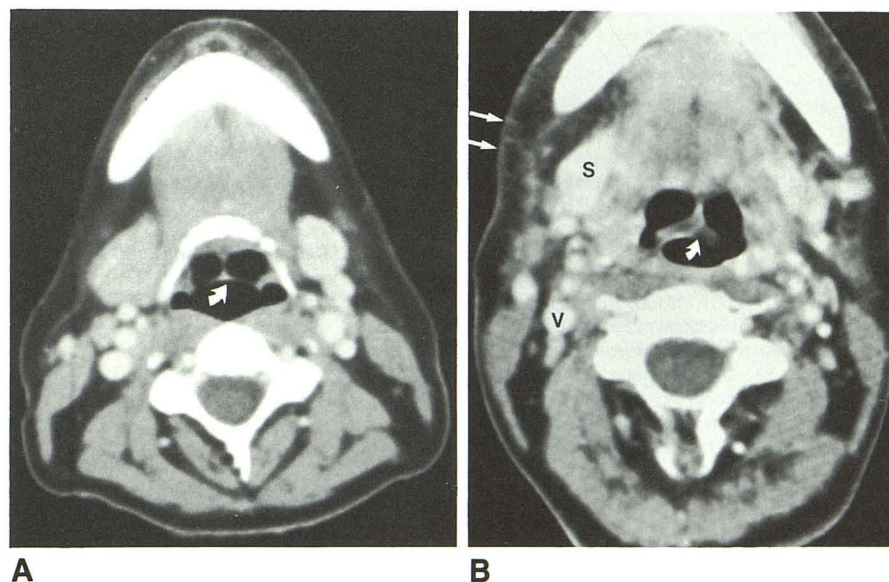


TABLE 2: Frequency of Epiglottic Thickening Among Treatment Groups

	Radiation and Surgery (n = 15)	Radiation Only (n = 6)	Surgery Only (n = 19)	Before Treatment (n = 37)
Epiglottis $\leq$ 4 mm thick	5 (33%)	2 (33%)	18 (95%)	33 (89%)
Epiglottis > 4 mm thick	10 (67%)	4 (67%)	1 (5%)	4 (11%)
Epiglottis > 4 mm thick and no tumor involvement	7 (47%)	3 (50%)	0	2 (5%)

Fig. 2.—A, Normal-appearing epiglottis (arrow) in a patient with liposarcoma of the base of the tongue 4 months after resection but just before radiation therapy.

B, Thickened epiglottis (curved arrow) in same patient 15 months after completion of 2200 rad (22.0 Gy) of neutron radiation. Note mild stranding of right subcutaneous fat (straight arrows) and abnormally dense right submandibular gland (S), nearly isodense with internal jugular vein (V), associated with radiation.



theless, attempting to distinguish findings resulting from previous treatment from those caused by recurrent neoplasm may be helpful clinically.

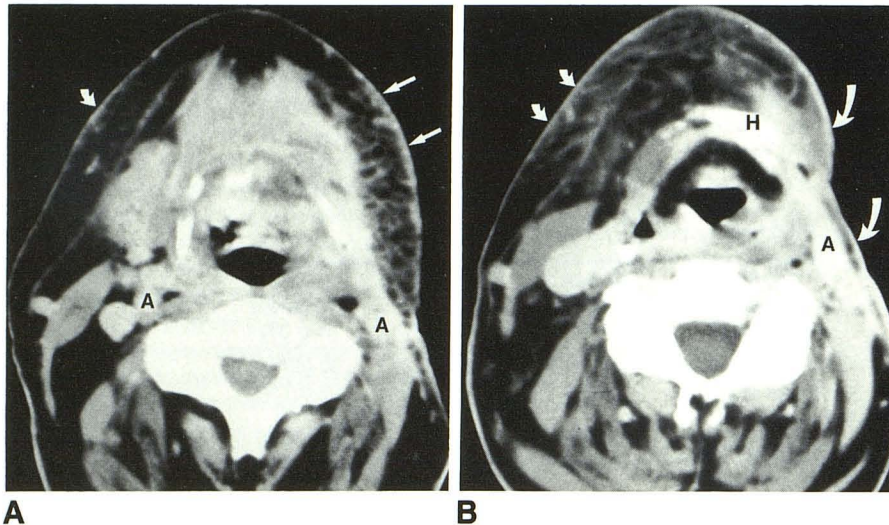
The present retrospective study attempted to distinguish postradiation effects from other factors by analyzing several treatment variables in conjunction with CT findings. We attributed soft-tissue changes to postradiation effects only when

they occurred on the contralateral side or at a site distant from obvious tumor or the site of previous surgery. Although soft-tissue changes in proximity to tumor or surgery may have been caused predominantly by radiation therapy, these changes were not considered to be radiation related in the final analysis. Consequently, our results may underestimate the true frequency of radiation-induced soft-tissue changes.



**TABLE 3: Frequency of Infiltration of Subcutaneous Fat in the Subhyoid and/or Suprahyoid Regions**

	Radiation and Surgery (n = 27)	Radiation Only (n = 10)	Surgery Only (n = 24)	Before Treatment (n = 41)
Infiltration of subcutaneous fat close to tumor or surgery	23 (85%)	6 (60%)	12 (50%)	9 (22%)
Infiltration of subcutaneous fat distant from tumor or surgery	15 (56%)	6 (60%)	6 (25%)	5 (12%)



**Fig. 3.—A**, Moderate stranding of left subcutaneous fat (*straight arrows*) associated with surgery and/or radiation, and mild stranding of right subcutaneous fat (*curved arrow*) associated with radiation, in a patient with left piriform sinus squamous cell carcinoma 3 weeks after completion of 6660 rad (66.6 Gy) photons and 16 weeks after left radical neck dissection with composite resection. Note obliteration of left pericarotid fat planes.

**B**, Confluent obliteration of left subcutaneous fat (*large curved arrows*) and more severe right subcutaneous fat stranding (*small curved arrows*) at level of hyoid bone (H), slightly more caudal than Fig. 3A. A = carotid artery.

**TABLE 4: Frequency of Infiltration of Fat in the Parapharyngeal, Pericarotid, Preepiglottic, Paralaryngeal Regions, and Posterior Neck**

	Radiation and Surgery	Radiation Only	Surgery Only	Before Treatment
Parapharyngeal region:				
Infiltration of fat close to tumor or surgery	10/25 (40%)	5/10 (50%)	6/24 (25%)	10/40 (25%)
Infiltration of fat distant from tumor or surgery	0/25	1/10 (10%)	1/24 (4%)	0/40
Pericarotid region:				
Infiltration of fat close to tumor or surgery	20/27 (74%)	4/8 (50%)	13/23 (57%)	12/39 (31%)
Infiltration of fat distant from tumor or surgery	4/27 (15%)	1/8 (13%)	3/23 (13%)	0/39
Preepiglottic and/or paralaryngeal:				
Infiltration of fat close to tumor or surgery	15/23 (65%)	3/8 (38%)	7/22 (32%)	6/39 (15%)
Infiltration of fat distant from tumor or surgery	2/23 (9%)	1/8 (13%)	2/22 (9%)	1/39 (3%)
Posterior neck:				
Infiltration of fat close to tumor or surgery	1/27 (4%)	0/9	0/24	2/40 (5%)
Infiltration of fat distant from tumor or surgery	0/27	0/9	0/24	0/40

Patients who had previous treatment showed a significantly higher frequency of skin thickening than did patients who had not received treatment. However, the effects of radiation treatment could not always be distinguished reliably from

effects of earlier surgical treatment. Skin ulceration or fibrosis due to radiation has been estimated to occur within 5 years in 1–5% of patients who have received 5500 rads, and 25–50% of patients who have received 7000 rads under certain



standardized conditions [14]. A more severe skin reaction has been reported on curved intertriginous surfaces or when the skin has received tangential radiotherapy [1]. For this reason, skin reaction may be more severe in patients with head and neck tumors than in those with tumors in other body sites.

Before either surgery or radiation the epiglottis measured less than or equal to 4 mm in thickness near its cephalad tip in 94% of patients who had no epiglottic tumor involvement. Epiglottic thickening ( $>4$  mm) was observed at a significantly higher frequency after radiation therapy than before such treatment. Nevertheless, at least one patient in each treatment group had epiglottic thickening from tumor involvement. Epiglottic enlargement has been previously noted in two children with head and neck malignancies after radiation and chemotherapy [4]. Mancuso and Hanafée [2] attributed post-radiation thickening of the epiglottis, aryepiglottic folds, and false cords to lymphedema. Supraglottic edema persisting 2–7 years after radiation has also been demonstrated on MR imaging [15].

Stranding of subcutaneous fat in areas distant from tumor or before surgery was seen at a significantly higher frequency in patients after radiation therapy than before such treatment. However, subcutaneous fat stranding distant from tumor or surgery was still seen in a small percentage of patients who had not received any radiation treatment. Subcutaneous stranding and skin thickening have previously been noted in postradiation patients with head and neck tumors, but the frequency of this observation has not been reported [2]. A similar appearance has been described in the chest wall after radiation therapy for breast carcinoma [16]. In the present series, a higher percentage of patients demonstrated stranding of subcutaneous fat than skin thickening after radiation therapy, suggesting that this is a more sensitive sign of previous radiation.

Unlike stranding of subcutaneous fat, stranding of deep cervical fat (parapharyngeal, preepiglottic, perilaryngeal, and perivascular regions) could not reliably be ascribed to postradiation effects and could not be distinguished from tumor and postsurgical effects. Other authors have suggested that previous radiation obscures tissue planes around tumor and causes stranding in the perivascular fat [2, 17].

We conclude that soft-tissue changes of the head and neck on CT, especially epiglottic thickening and stranding of subcutaneous fat, can commonly be attributed to previous radia-

tion therapy. However, these postradiation effects are not always distinguishable from postsurgical effects and tumor.

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