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Swallowing Disorders in the First Year After Radiation and Chemoradiation

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Abstract

Background—Radiation alone or concurrent chemoradiation can result in severe swallowing disorders. This manuscript defines the swallowing disorders occurring at pretreatment and 3 and 12 months after completion of radiation or chemoradiation.

Methods—Forty-eight patients (10 women and 38 men) participated in this study involving videofluorographic evaluation of oropharyngeal swallow at the 3 time points.

Results—At baseline, patients had some swallow disorders, probably related to presence of their tumor. At 3 months posttreatment, frequency of reduced tongue base retraction, slow or delayed laryngeal vestibule closure, and reduced laryngeal elevation increased from baseline. Some disorders continued at 12 months posttreatment. Functional swallow decreased over time in patients treated with chemoradiation, but not those treated with radiation alone.

Discussion—Chemoradiation results in fewer functional swallowers than radiation alone at 12 months posttreatment completion.

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Keywords

radiation; chemoradiation; oropharyngeal swallowing disorders; oropharyngeal swallowing physiology; head and neck; videofluoroscopy

Concurrent chemoradiation has emerged as an effective treatment strategy for advanced cancers of the head and neck.[1–4] There are a number of studies that examine oropharyngeal swallowing function in patients treated with chemoradiation. These studies typically have utilized small numbers of patients (under 20) or have completed assessment of swallow function at short-term time points (6 months after completion of chemoradiation or less) or at variable time points.[5] Eisbruch et al[6] examined swallowing with videofluoroscopy before treatment and early (1–3 months) versus late (6–12 months) after chemoradiation in 26 patients treated with concurrent radiotherapy and gemcitabine and compared them with 6 patients treated with concurrent radiotherapy and high-dose intra-arterial cisplatin. These windows for assessment were rather large for comparison of swallow physiology in these patients. The authors found similar swallowing disorders after both treatment regimens: weakness of posterior motion of the base of the tongue, lack of coordination of swallow phases, reduced elevation of the larynx and reduced laryngeal closure, and reduced epiglottic inversion. Prolonged pharyngeal transit times were also noted, as was frequent silent aspiration (foods or liquid entering the airway with no cough or other notable visual or audible responses). Hughes et al[7] found similar swallowing disorders and silent aspiration in patients treated with radiotherapy for nasopharyngeal cancer. These disorders are the same as those seen in patients treated with radiation therapy and sequential chemotherapy.[8] This present manuscript examines oropharyngeal swallow function in a larger number of patients treated with radiation alone (n = 12) or chemoradiation (n = 36) at 3 specific time points: baseline, first postchemoradiation assessment at 3 months, and again at 1 year posttreatment completion. All 48 patients had all 3 assessments.

Materials and Methods

This was a prospective study funded by the National Cancer Institute and the National Institute on Dental Research. All procedures were approved by the institutional review board for studies involving human subjects at each participating institution. Patients included 48 individuals, 38 men and 10 women, who had been diagnosed with oropharyngeal cancers, including 3 patients with tumors of the nasopharynx, 21 individuals with oropharyngeal tumors, 3 with hypopharyngeal tumors, and 21 with laryngeal tumors, as shown in Table 1. One patient had stage I disease, and 7 patients had stage II disease. The remaining patients had advanced disease (stages III and IV). Age range was to 38 to 76 years. All but 12 patients received high-dose chemotherapy, concurrent with high-dose radiotherapy. Six of these also received induction chemotherapy. Twelve patients received only radiotherapy and no chemotherapy. Radiotherapy dose ranged from 6500 to 7920 cGy for all 48 patients. Intensity modulated radiation therapy (IMRT) was not used in any of the subjects in this study.

All patients were examined with videofluoroscopic studies of oropharyngeal swallow at 3 points in time: before treatment began (baseline) and 3 months and 12 months posttreatment. At each of the 3 assessment points, the protocol for the radiographic study was the same. Patients were given 14 swallows, including 2 swallows each of 1, 3, 5, and 10 mL of thin liquids (E-Z-EM thin liquid barium), 2 swallows while cup drinking (E-Z-EM thin liquid barium), 3 mL barium paste (E-Z-EM barium paste), and masticated material (1/4 of a Lorna Doone cookie coated with 1 mL barium paste [E-Z-EM barium paste, E-Z-EM Company, NY]).

Each videofluoroscopic study was reviewed in real time, slow motion, and frame by frame to identify the presence of a functional swallow, ie, swallows with longer pharyngeal delay, greater oral, and/or pharyngeal residue than normal swallows in patients with the same age and sex but no aspiration and any of the following swallowing disorders: reduced tongue base retraction, reduced tongue strength, delayed pharyngeal swallow, slowed or delayed vestibule closure, reduced tongue control, reduced anteroposterior tongue movement, reduced laryngeal elevation, reduced tongue stabilization, bilateral pharyngeal weakness, reduced cricopharyngeal opening, visible cricopharyngeal bar, and incomplete laryngeal vestibule closure.[9] Delayed vestibule closure indicates that the laryngeal entrance or vestibule does not close in a timely fashion and enables penetration of food or liquid into the larynx. This is a prominent finding among patients treated with chemoradiation. Ten percent of all videofluoroscopic studies were reexamined by the same and a different observer to determine interobserver and intraobserver reliability, which were .99 and 1.0, respectively.

In addition, data were collected on the percent of the patient's diet taken orally, the consistencies included in each patient's diet, and the patient's stimulated saliva weight as measured. At each evaluation point, the patient's stimulated whole saliva production (from all salivary glands) was quantified by taking the difference of the weight in grams of a 4″ × 4″ gauze pad before and after chewing for 2 minutes.[10] Measuring output from all salivary glands is an excellent index of the saliva available for eating and swallowing, and therefore is an appropriate measure for this study.

Percentages were compared across the 3 time points using Cochran's Q test, with $p < .05$ as the criterion for significance. Three pairwise comparisons were made among the 3 time points, each using McNemar's test and using the Bonferroni corrected $p < .0167$ (=.05/3) as the criterion for significance. Saliva weight was analyzed using repeated measures analysis of variance and pairwise *t* tests, with the above criteria for significance.

Results

All 48 patients exhibited swallowing disorders pretreatment, probably related to their tumor. Their baseline frequency ranged from 6% to 67%. Reduced tongue base retraction (67%), reduced tongue strength (51%), and a delay in triggering the pharyngeal swallow (40%) were the most frequent disorders (Table 2). For all 48 patients, the rates of reduced tongue base retraction, delayed vestibule closure, reduced anteriorposterior (A-P) tongue movement, and reduced laryngeal elevation changed (increased) over the 3 time points, with all (except reduced laryngeal elevation) increasing significantly between baseline and 3 months. Delayed vestibule closure and reduced A-P tongue movement maintained this significant increase to 12 months. At 3 months posttreatment, the frequency on the 9 other disorders worsened, but not significantly so. For no disorder did the frequency of occurrence change significantly between 3 and 12 months.

The frequency of functional swallow decreased significantly from 98% at baseline to 79% at 3 months ($p = .003$). At the same time, the percent of patients eating less than 50% orally increased significantly at 3 months and decreased significantly at 12 months. Percent of patients eating a normal diet as defined above dropped significantly from 79% at baseline to 46% at 3 months posttreatment with no significant change at 12 months posttreatment. During this same time period, the patients' saliva weight dropped significantly from baseline (5.68 g) to 3 months posttreatment (1.99 g) and stayed at that level at 12 months posttreatment.

At 12 months posttreatment, 5 patients had a G-tube in place and 2 patients had a tracheostomy.

Site of Disease

When similar analyses were done for 21 patients with oropharyngeal cancer (Table 3), delayed vestibule closure increased in frequency at 3 months and remained increased to 12 months. Bilateral pharyngeal weakness increased significantly from baseline to 12 months. Other disorders indicated some statistical significance but were not strong enough to show consistent results over time. Oral intake and normal diet worsened between baseline and 3 months posttreatment. Saliva weight decreased significantly at 3 months and remained low at 12 months.

When similar analyses were done for 21 patients with laryngeal cancer (Table 4), reduced A-P tongue movement increased significantly at 3 months and continued to be increased at 12 months. Mean saliva weight dropped significantly at 12 months posttreatment.

Type of Treatment

Examination of the frequency of swallowing disorders in the 12 patients who were treated with radiotherapy only (Table 5) revealed no significant changes in frequency of swallow disorders, percent of patients with functional swallow, percent taking less than 50% oral intake, and percent taking a normal diet between baseline, 3 months, and 12 months posttreatment. In contrast, for the 36 patients treated with chemoradiation (Table 6), the frequency of swallowing disorders increased significantly over time posttreatment for 6 disorders (reduced tongue base retraction, slow/delayed vestibule closure, reduced A-P tongue movement, reduced laryngeal elevation, bilateral pharyngeal weakness, and reduced cricopharyngeal opening) with significant increases between baseline and 3 months posttreatment for all of these disorders, except reduced A-P tongue movement and reduced laryngeal elevation. Three of these disorders (reduced tongue base retraction, slowed-delayed vestibule closure, and reduced A-P tongue movement) remained significantly more frequent than baseline at 12 months posttreatment. Overall, no disorders differed significantly in frequency between 3 and 12 months. The percentage of patients with a functional swallow decreased significantly after cancer treatment. Percent of patients eating less than 50% of their nutrition orally increased significantly at 3 months posttreatment and then returned to baseline levels at 12 months posttreatment. The percent of patients eating a normal diet dropped significantly at 3 months posttreatment and did not demonstrate further change. Saliva weight dropped at 3 months and remained there at 12 months.

Site of Disease and Type of Treatment

Only 2 sites (larynx and oropharynx) had enough patients to examine separately. Ten patients with laryngeal cancer were treated with radiotherapy alone and 11 were treated with chemoradiation. All 10 treated with radiotherapy alone exhibited functional swallows throughout the year of the study (Table 7), and their level of swallowing disorders, percent on oral intake, and percent on normal diet did not change throughout the year. At baseline, the 11 patients with laryngeal cancer treated with chemoradiation (Table 8) exhibited functional swallows, but only 73% maintained functional swallows throughout the rest of the study, whereas a significant drop in saliva weight occurred between baseline and 3 and 12 months posttreatment. This group indicated some significant variability in level of swallowing disorders over time, but these differences were not strong enough to result in significant pairwise comparisons. The profile of swallowing disorders in both groups of patients with laryngeal cancer was similar to that of all patients shown in Table 2.

There were 19 patients with oropharyngeal site of disease treated with chemoradiation and only 2 treated with radiotherapy alone. In those treated with chemoradiation (Table 9), significant changes were seen across time for reduced tongue base retraction and delayed vestibule closure. The profile of swallow disorders was the same as in the entire group of 36

chemoradiated patients. Ninety-four percent of these patients exhibited a functional swallow at baseline, 74% at 3 months after treatment, and 84% at 12 months post baseline. These differences were not statistically significant for the frequency of functional swallows. Percent of patients exhibiting less than 50% oral intake or normal diet showed significant overall changes over time but not significant pairwise comparisons. Saliva weight dropped significantly from baseline to 3 months posttreatment.

Discussion

This study examined the swallowing disorders occurring in 12 patients treated with radiotherapy and 36 treated with chemoradiation. Each patient's swallow was examined videofluoroscopically at 3 points in time beginning prior to their treatment (baseline) and at 3 months and 12 months after treatment completion. Physiologic and anatomic swallowing disorders were specifically identified in detail in this present study. Other authors have described swallow symptoms,[5] such as stasis of the bolus, vallecular residue, and aspiration, rather than physiologic or anatomic disorders causing these symptoms. Still others have used a combination of symptoms and physiologic swallow problems, such as prolonged pharyngeal transit times and lack of coordination, between swallowing phases.[6] All of these differences in classification make comparisons of observations of swallow dysfunction very difficult. Results for the group as a whole showed no significant improvement in swallow across the first year posttreatment. In fact, the frequency of several swallowing disorders did increase significantly in that year. This result and the observations of other investigators[3,5] emphasize the need to follow these patients regularly with swallow assessments, preferably modified barium swallows, to identify any worsening problems. It is also important to alert patients to notify their physicians if their swallow seems to worsen.

In our study, the site of disease did not appear to affect the nature of swallowing disorders. However, most of the patients had stage III or IV disease and were treated with large radiation fields using conventional radiation techniques encompassing several organs important to the swallowing mechanism. The number of patients was too small to enable careful statistical comparison of the disorders observed in each patient group based on tumor location. As large numbers of patients are collected and more sophisticated conformal radiation techniques of 3-dimensional conformal radiotherapy (3D-CRT) and IMRT are being used, the differences in swallow disorders might be identifiable and the exact port of study and swallow disorders could be examined and correlated with tumor site, radiation dose, and radiation techniques.

Twenty-seven of the patients had received swallowing therapy designed to improve or maintain oral and pharyngeal range of motion. The median number of minutes of therapy was 70 minutes, with a range of 10 to 680 minutes. The median number of therapy sessions was 4, with a range of 1 to 21 sessions. This study was not designed to examine the effects of swallowing therapy, but it may be hypothesized from these results that without therapy these patients' swallowing may have been worse.

Fifty-six percent of the patients in this study received swallowing therapy. Ideally, every patient in need of swallowing rehabilitation would obtain the treatment needed. However, factors other than need influence whether a patient receives therapy. Monetary issues have a major impact on the provision of swallowing therapy. Many insurance plans either do not cover rehabilitative services or limit the number of therapy sessions that will be reimbursed. The financial burden of paying for swallowing therapy services may be prohibitive and prevent those with the greatest need from obtaining the services they require. Physical access to therapy services may also be problematic. Many patients who live in remote areas need to travel for hours to obtain rehabilitative services. Issues such as these may have had an impact on the ability of patients in this study to obtain the swallowing therapy they needed.

A relatively small proportion of patients in this present study (27) received swallowing therapy. The reason for this low application of therapy may be as described above. However, whether or not patients should get swallowing exercise and therapy independent of their swallowing function and who should be selected, has been recently studied by Kulbersh et al.[11] These authors found an improvement in swallow function posttreatment in patients who received pretreatment swallow therapy. The difficulty with this type of study to examine swallowing therapy effectiveness is that with chemoradiation, many patients do not feel well enough to complete the required exercises and practice.

A high proportion of the patients had functional swallows despite the presence of swallowing disorders, particularly in patients treated with radiation alone. By definition, a functional swallow means no aspiration and minimal residue. The low rate of aspiration in these patients is different from other manuscripts that have reported up to 75% of patients after radiation or chemoradiation who aspirate. Perhaps the difference relates to the fact that these patients received swallowing therapy designed to maintain or improve range of motion in the pharynx.

Bolus volume in our study was carefully managed, such that patients started with 1 mL moved to 3, 5, and then 10 mL, and cup drinking as each patient demonstrated safe swallows. If the swallow was unsafe, the volume was not increased. In earlier studies, authors have not defined the volume used nor controlled it throughout the study. This is likely to cause the larger rate of aspiration seen in other manuscripts. Controlling volume is 1 major way to reduce the volume of aspirated material.

A number of swallow motility disorders were analyzed in this study, and many occurred with great frequency in patients over the first year posttreatment. In a separate study,[12] the investigators examined which swallow motility disorders observed on videofluorography were significantly associated with limitations in oral intake and food consistencies included in the diet of patients treated with chemoradiotherapy for head and neck cancer. The results of that study showed that limitations in oral intake and diet after cancer treatment were significantly related to reduced laryngeal elevation, reduced cricopharyngeal opening, and rating of nonfunctional swallow. Although other motility disorders were observed, they were not differentially related to oral intake and diet.

Despite the fact that some clinicians believe that swallowing disorders improve in these patients, the swallow disorders observed in the patients in this study did not improve or disappear in the first year after tumor treatment and, in fact, there is some preliminary evidence that swallowing physiology in patients treated with radiotherapy may worsen over the next several years posttreatment,[8] indicating the need for continued research, if possible, to follow these patients with regular radiographic assessments of swallowing.

The swallowing disorders observed in these patients were similar in both those who had chemoradiation and those who had radiation only. Chemotherapy seemed to increase the frequency of these disorders, but not the nature of them. Since it is known that concurrent chemotherapy and radiotherapy increases the effectiveness of radiotherapy, we may hypothesize that the swallowing disorders seen in these patients are the result of tissue changes from radiation, not chemotherapy, and that chemotherapy only increases their severity and frequency. The lower frequency of functional swallowers posttreatment, greater number of patients taking less than 50% oral intake, and the lower percent of patients on a normal diet in those treated with chemoradiation reinforces this theory. Further research is needed to further clarify the effects of chemotherapy on swallow function. Therapeutic protocols now need to focus on the exact therapy exercises for the ports of radiation and whether or not IMRT can reduce the effects of radiation on swallowing function.

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References

1. Hirsch SM, Caldarelli DD, Hutchinson JC, et al. Concomitant chemotherapy and split-course radiation for cure and preservation of speech and swallowing in head and neck cancer. Laryngoscope 1991;101:583–586. [PubMed: 2041436]
2. Koch WM, Lee DJ, Eisele DW, et al. Chemoradiotherapy for organ preservation in oral and pharyngeal carcinoma. Arch Otolaryngol Head Neck Surg 1995;121:974–980. [PubMed: 7646865]
3. Kotz T, Costello R, Li Y, Posner MR. Swallowing dysfunction after chemoradiation for advanced squamous cell carcinoma of the head and neck. Head Neck 2004;26:365–372. [PubMed: 15054740]
4. Milas L, Mason KA, Liao Z, Ang KK. Chemoradiotherapy: emerging treatment improvement strategies. Head Neck 2003;25:152–167. [PubMed: 12509799]
5. Nguyen NP, Moltz CC, Frank C, et al. Dysphagia following chemoradiation for locally advanced head and neck cancer. Ann Oncol 2004;15:383–388. [PubMed: 14998839]
6. Eisbruch A, Schwartz M, Rasch C, et al. Dysphagia and aspiration after chemoradiotherapy for head-and-neck cancer: which anatomic structures are affected and can they be spared by IMRT? Int J Radiat Oncol Biol Phys 2004;60:1425–1439. [PubMed: 15590174]
7. Hughes PJ, Scott PMJ, Kew J, et al. Dysphagia in treated nasopharyngeal cancer. Head Neck 2000;22:393–397. [PubMed: 10862024]
8. Lazarus CL, Logemann JA, Pauloski BR, et al. Swallowing disorders in head and neck cancer patients treated with radiotherapy and adjuvant chemotherapy. Laryngoscope 1996;106:1157–1166. [PubMed: 8822723]
9. Logemann, JA. Evaluation and treatment of swallowing disorders. 2nd. Austin, Texas: Pro-Ed Publishers; 1998. p. 406p
10. Kohler PF, Winter ME. A quantitative test for xerostomia: the Saxon test. Arthritis Rheum 1985;28:1128–1132. [PubMed: 4052124]
11. Kulbersh BD, Rosenthal EL, McGrew BM, et al. Pretreatment, preoperative swallowing exercises may improve dysphagia quality of life. Laryngoscope 2006;116:883–886. [PubMed: 16735913]
12. Pauloski BR, Rademaker AW, Logemann JA, et al. Relationship between swallow motility disorders on videofluorography and oral intake in patients treated for head and neck cancer with radiotherapy with or without chemotherapy. Head Neck 2006;28:1069–1076. [PubMed: 16823874]

Table 1

Age, sex, race, site and stage of disease, total radiotherapy dose (cGy) to the primary, fractionation schedule, and drugs given by induction and concurrence.

							Induction			Concurrent			
Age, y	**Sex**	**Race**	**Site**	**Stage**	**Total delivered dose to primary, cGy**	**QD/BID**	**Chemotherapy**	**Drug 1**	**Drug 2**	**Drug 1**	**Drug 2**	**Drug 3**	**Drug 4**
49.73	Female	Hispanic	Nasopharynx	4	7050	BID	Yes	Carboplatin	Paclitaxel	Paclitaxel	5-FU	Hydroxyurea	
50.24	Female	White	Nasopharynx	4	7000	BID	No			Paclitaxel	5-FU	Hydroxyurea	Epoetin α
66.38	Male	Black	Nasopharynx	4	7050	BID	No			Paclitaxel	5-FU	Hydroxyurea	
66.11	Male	White	Oropharynx	2	7350	BID	No			Paclitaxel	5-FU	Hydroxyurea	
70.86	Male	White	Oropharynx	2	7350	BID	No			Cisplatin	5-FU	Hydroxyurea	
60.21	Male	White	Oropharynx	3	7000	QD	No			Cisplatin (RADPLAT)			
62.01	Female	White	Oropharynx	3	6800	QD	No				5-FU	Hydroxyurea	
65.27	Male	White	Oropharynx	3	7050	BID	No			Paclitaxel	5-FU	Hydroxyurea	
62.73	Male	White	Oropharynx	4	7200	BID	Yes	Carboplatin	Paclitaxel	Paclitaxel	5-FU	Hydroxyurea	
57.22	Male	White	Oropharynx	4	7050	BID	Yes	Carboplatin	Paclitaxel	Paclitaxel	5-FU	Hydroxyurea	
55.89	Male	White	Oropharynx	4	7000	QD	No			Cisplatin	5-FU		Amifostine
55.19	Male	White	Oropharynx	4	6600	QD	No			Cisplatin			
69.07	Female	White	Oropharynx	4	7000	QD	No			Paclitaxel	Cisplatin		
74.68	Male	White	Oropharynx	4	7150	QD	No			Cisplatin	5-FU		
37.59	Female	Black	Oropharynx	4	7500	BID	No			Paclitaxel	5-FU	Hydroxyurea	
54.16	Male	White	Oropharynx	4	7000	QD	No				5-FU	Hydroxyurea	
65.95	Male	Black	Oropharynx	4	7650	BID	No			Paclitaxel	5-FU	Hydroxyurea	
69.02	Male	White	Oropharynx	4	7000	QD	No			Cisplatin (RADPLAT)			
55.39	Male	Hispanic	Oropharynx	4	6800	QD	No			Cisplatin	5-FU		
60.12	Male	White	Oropharynx	4	7400	BID	No			Paclitaxel	5-FU	Hydroxyurea	
51.84	Male	White	Oropharynx	4	6630	QD	No			Cisplatin (RADPLAT)			
48.63	Male	White	Oropharynx	4	7350	BID	No			Paclitaxel	5-FU	Hydroxyurea	
73.94	Male	White	Oropharynx	4	7400	QD	No						
71.78	Male	White	Oropharynx	4	7000	QD	No						
65.38	Male	White	Hypopharynx	3	7000	QD	No			Paclitaxel	Cisplatin		
74.24	Male	White	Hypopharynx	3	7000	QD	No				5-FU	Hydroxyurea	
52.17	Male	White	Hypopharynx	4	7050	BID	No			Paclitaxel	5-FU	Hydroxyurea	

							Induction			Concurrent			
Age, y	**Sex**	**Race**	**Site**	**Stage**	**Total delivered dose to primary, cGy**	**QD/BID**	**Chemotherapy**	**Drug 1**	**Drug 2**	**Drug 1**	**Drug 2**	**Drug 3**	**Drug 4**
64.83	Male	White	Larynx	1	6600	QD	No						
68.94	Male	White	Larynx	2	6500	QD	No						
44.18	Male	White	Larynx	2	7920	BID	No						
56.76	Male	White	Larynx	2	7920	BID	No						
75.72	Female	White	Larynx	2	7000	QD	No						
57.79	Male	White	Larynx	2	7000	QD	No						
39.74	Female	White	Larynx	3	7100	QD	No			Cisplatin (RADPLAT)			
60.66	Male	Black	Larynx	3	6900	BID	No				5-FU	Hydroxyurea	
51.45	Female	White	Larynx	3	7050	BID	No				5-FU	Hydroxyurea	
61.18	Male	White	Larynx	3	7000	QD	No			Cisplatin (RADPLAT)			
75.59	Male	Black	Larynx	3	7020	QD	No						
62.36	Male	White	Larynx	3	7884	BID	No						
43.58	Male	Black	Larynx	4	7500	BID	Yes	Carboplatin	Paclitaxel	Paclitaxel	5-FU	Hydroxyurea	
53.33	Male	Black	Larynx	4	7350	BID	Yes	Carboplatin	Paclitaxel	Paclitaxel	5-FU	Hydroxyurea	
50.35	Male	White	Larynx	4	7200	BID	Yes	Carboplatin	Paclitaxel	Paclitaxel	5-FU	Hydroxyurea	
55.98	Female	White	Larynx	4	7050	BID	No			Paclitaxel	5-FU	Hydroxyurea	
59.52	Male	White	Larynx	4	7000	QD	No			Cisplatin	5-FU		
70.47	Male	Black	Larynx	4	7200	QD	No			Cisplatin (RADPLAT)			
51.62	Female	Black	Larynx	4	7400	BID	No			Paclitaxel	5-FU	Hydroxyurea	Epoetin α
56.30	Male	White	Larynx	4	7000	QD	No						
56.20	Male	White	Larynx	4	7000	QD	No						

Abbreviations: QD, once per day; BID, twice per day; 5-FU, 5-fluorouracil.

Table 2

Percent of oropharyngeal swallowing disorders and other measures of swallowing observed at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value		
	Baseline, %	**3 mo, %**	**12 mo, %**	**Overall *p* value by Cochran's Q**	**Baseline vs 3 mo**	**Baseline vs 12 mo**	**3 vs 12 mo**
Description of disorder							
Reduced tongue base retraction	67	90	85	**.0033**	**.002**	.02	.48
Reduced tongue strength	51	60	57	.63	.37	.41	.83
Delayed pharyngeal swallow	40	56	42	.08	.03	.81	.05
Slowed/delayed vestibule closure	27	60	54	**.0009**	**.0006**	**.005**	.49
Reduced tongue control	33	46	38	.25	.03	.62	.32
Reduced A-P tongue movement	25	46	56	**.002**	**.01**	**.002**	.23
Reduced laryngeal elevation	17	31	35	**.04**	.03	.02	.59
Reduced tongue stabilization	15	13	15	.92	.65	.99	.74
Bilateral pharyngeal weakness	8	23	21	.12	.05	.08	.80
Reduced cricopharyngeal opening	8	23	21	.07	.03	.08	.74
Visible cricopharyngeal bar	10	17	15	.56	.26	.48	.74
Incomplete laryngeal vestibule closure	6	10	13	.56	.41	.32	.74
Other measures of swallowing							
Functional swallow	98	79	83	**.004**	**.003**	.02	.41
% Oral intake <50%	2	25	10	**.0002**	**.0009**	.045	**.008**
% Normal diet	79	46	60	**.0004**	**.0003**	.029	.052
Mean saliva weight (in grams)	5.68	1.99	1.92	**.024**	<**.0001**	<**.0001**	.91
SEM	0.50	0.52	0.33				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate $p < .05$ for overall test or $p < .017$ for pairwise test.

Table 3

Percent of oropharyngeal swallowing disorders observed in the 21 patients with oropharyngeal cancer at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	71	100	86	No test	No test	.26	No test
Reduced tongue strength	45	60	70	.18	.26	.06	.48
Delayed pharyngeal swallow	38	62	57	.12	.06	.16	.65
Slowed/delayed vestibule closure	29	71	67	**.01**	**.007**	**.011**	.71
Reduced tongue control	38	48	33	.42	.16	.71	.26
Reduced A-P tongue movement	48	48	62	.32	.99	.26	.08
Reduced laryngeal elevation	5	19	33	.05	.08	.03	.26
Reduced tongue stabilization	25	15	15	.45	.32	.32	.99
Bilateral pharyngeal weakness	5	29	33	**.045**	.03	**.014**	.74
Reduced cricopharyngeal opening	0	19	19	.10	No test	No test	.99
Visible cricopharyngeal bar	10	24	10	.32	.18	.99	.26
Incomplete laryngeal vestibule closure	0	10	14	.25	No test	No test	.65
Other measures of swallowing							
Functional swallow	95	71	86	.07	.025	.32	.18
% Oral intake <50%	5	33	10	**.0057**	**.014**	.32	.025
% Normal diet	86	48	52	**.0087**	**.011**	**.0082**	.71
Mean saliva weight (in grams)	5.02	0.59	0.87	<**.0001**	<**.0001**	<**.0001**	.14
SEM	0.51	0.08	0.16				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate $p < .05$ for overall test or $p < .017$ for pairwise test. ("No test" means frequencies were too low to perform a statistical test).

Table 4

Percent of oropharyngeal swallowing disorders observed in the 21 patients with laryngeal cancer at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	67	81	86	.16	.18	.10	.56
Reduced tongue strength	57	62	43	.34	.74	.18	.21
Delayed pharyngeal swallow	38	52	29	.18	.26	.48	.06
Slowed/delayed vestibule closure	24	52	48	.08	.034	.06	.74
Reduced tongue control	38	43	38	.87	.56	.99	.65
Reduced A-P tongue movement	5	48	52	**.002**	**.003**	**.004**	.74
Reduced laryngeal elevation	24	38	33	.50	.26	.41	.71
Reduced tongue stabilization	10	14	19	.65	.32	.41	.71
Bilateral pharyngeal weakness	10	24	14	.46	.26	.65	.41
Reduced cricopharyngeal opening	10	19	19	.56	.41	.41	.99
Visible cricopharyngeal bar	14	14	24	.37	.99	.32	.16
Incomplete laryngeal vestibule closure	10	10	14	.82	.99	.65	.56
Other measures of swallowing							
Functional swallow	100	86	86	No test	No test	No test	No test
% Oral intake <50%	0	19	10	**.05**	No test	No test	.16
% Normal diet	71	48	67	**.045**	.059	.71	.046
Mean saliva weight (in grams)	6.71	3.74	3.28	.14	.047	**.006**	.71
SEM	0.97	1.06	0.62				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate p < .05 for overall test or p < .017 for pairwise test. (“No test” means frequencies were too low to perform a statistical test).

Table 5

Percent of oropharyngeal swallowing disorders observed in the 21 patients with head and neck cancer treated with radiation only at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	83	83	83	.99	.99	.99	.99
Reduced tongue strength	67	50	50	.56	.41	.16	.99
Delayed pharyngeal swallow	42	58	33	.31	.32	.56	.18
Slowed/delayed vestibule closure	33	58	50	.25	.08	.32	.56
Reduced tongue control	50	58	42	No test	.32	.56	.16
Reduced A-P tongue movement	17	50	50	.17	.10	.10	.99
Reduced laryngeal elevation	8	17	25	.61	.56	.32	.65
Reduced tongue stabilization	17	17	25	No test	No test	.65	.65
Bilateral pharyngeal weakness	17	0	8	.37	No test	.56	No test
Reduced cricopharyngeal opening	17	0	8	.37	No test	.56	No test
Visible cricopharyngeal bar	25	33	41	.47	.32	.32	.56
Incomplete laryngeal vestibule closure	8	0	16	.37	No test	.56	No test
Other measures of swallowing							
Functional swallow	100	92	100.0	No test	No test	No test	No test
% Oral intake <50%	0	8	0	.37	No test	No test	No test
% Normal diet	92	67	75	No test	.083	.083	.99
Mean saliva weight (in grams)	6.14	5.71	4.40	.59	.86	.37	.51
SEM	1.65	1.73	0.88				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate $p < .05$ for overall test or $p < .017$ for pairwise test. ("No test" means frequencies were too low to perform a statistical test).

Table 6

Percent of oropharyngeal swallowing disorders observed in the 36 patients with head and neck cancer treated with chemoradiation at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	61	92	86	**.001**	**.0009**	**.013**	.41
Reduced tongue strength	46	63	60	.23	.11	.13	.81
Delayed pharyngeal swallow	39	56	44	.17	.06	.59	.16
Slowed/delayed vestibule closure	25	61	56	<**.001**	**.003**	**.008**	.62
Reduced tongue control	28	42	36	.33	.06	.41	.59
Reduced A-P tongue movement	28	44	58	**.008**	.06	**.008**	.13
Reduced laryngeal elevation	19	36	39	**.046**	.034	.035	.74
Reduced tongue stabilization	14	11	11	.87	.65	.65	.99
Bilateral pharyngeal weakness	6	31	25	**.019**	**.007**	.020	.59
Reduced cricopharyngeal opening	6	31	25	**.006**	**.003**	.020	.48
Visible cricopharyngeal bar	6	11	6	.61	.41	.99	.41
Incomplete laryngeal vestibule closure	6	14	11	.46	.18	.41	.71
Other measures of swallowing							
Functional swallow	97	75	78	**.006**	**.005**	.020	.65
% Oral intake <50%	3	31	14	**.0005**	**.0016**	.046	**.014**
% Normal diet	75	39	56	**.0024**	**.0016**	.052	.083
Mean saliva weight (in grams)	5.55	0.88	1.10	<**.0001**	<**.0001**	<**.0001**	.36
SEM	0.46	0.17	0.17				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate p < .05 for overall test or p < .017 for pairwise test.

Table 7

Percent of oropharyngeal swallowing disorders observed in the 10 patients with laryngeal cancer treated with radiation only at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	80	80	86	.99	.99	.99	.99
Reduced tongue strength	70	60	60	.61	.65	.16	.65
Delayed pharyngeal swallow	40	60	20	.09	.32	.16	.05
Slowed/delayed vestibule closure	30	50	40	.47	.16	.56	.56
Reduced tongue control	50	60	40	No test	.32	.56	.16
Reduced A-P tongue movement	10	50	40	.16	.05	.18	.65
Reduced laryngeal elevation	10	20	10	.78	.56	.99	.56
Reduced tongue stabilization	20	20	30	No test	No test	.65	.65
Bilateral pharyngeal weakness	20	0	0	No test	No test	No test	No test
Reduced cricopharyngeal opening	20	0	0	No test	No test	No test	No test
Visible cricopharyngeal bar	20	30	40	.22	.32	.16	.32
Incomplete laryngeal vestibule closure	10	0	10	.61	No test	.99	No test
Other measures of swallowing							
Functional swallow	100	100	100	No test	No test	No test	No test
% Oral intake <50%	0	0	0	No test	No test	No test	No test
% Normal diet	90	80	90	No test	.32	.99	.32
Mean saliva weight (in grams)	7.15	7.29	5.30	.48	.96	.40	.33
SEM	1.96	1.80	0.79				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate $p < .05$ for overall test or $p < .017$ for pairwise test. ("No test" means frequencies were too low to perform statistical tests).

Table 8

Percent of oropharyngeal swallowing disorders observed in the 11 patients with laryngeal cancer treated with chemoradiation at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value by McNemar's		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	55	82	91	**.039**	.08	.05	.32
Reduced tongue strength	45	64	36	.31	.32	.56	.18
Delayed pharyngeal swallow	36	45	36	.85	.56	.99	.56
Slowed/delayed vestibule closure	18	55	55	.14	.10	.05	.99
Reduced tongue control	27	27	36	.78	.99	.56	.56
Reduced A-P tongue movement	0	45	64	**.008**	No test	No test	.32
Reduced laryngeal elevation	36	55	55	.51	.32	.32	.99
Reduced tongue stabilization	0	9	9	.61	No test	No test	.99
Bilateral pharyngeal weakness	0	45	27	.07	No test	No test	.41
Reduced cricopharyngeal opening	0	36	36	**.041**	No test	No test	.99
Visible cricopharyngeal bar	9	0	9	.61	No test	.99	No test
Incomplete laryngeal vestibule closure	9	18	18	.72	.32	.56	.99
Other measures of swallowing							
Functional swallow	100	73	73	No test	No test	No test	No test
% Oral intake <50%	0	36	18	**.050**	No test	No test	.16
% Normal diet	55	18	45	.16	.10	.65	.083
Mean saliva weight (in grams)	6.40	1.25	1.46	**<.001**	**<.001**	**<.001**	.74
SEM	1.02	0.44	0.44				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate $p < .05$ for overall test or $p < .017$ for pairwise test. ("No test" means frequencies were too low to perform statistical tests).

Table 9

Percent of oropharyngeal swallowing disorders and other measures of swallowing observed in the 19 patients with oropharyngeal cancer treated with chemoradiation at pretreatment (baseline) and 3 and 12 mo posttreatment.

		Posttreatment			Pairwise *p* value by McNemar's		
	Baseline, %	3 mo, %	12 mo, %	Overall *p* value by Cochran's Q	Baseline vs 3 mo	Baseline vs 12 mo	3 vs 12 mo
Description of disorder							
Reduced tongue base retraction	68	100	84	**<.0001**	No test	.26	No test
Reduced tongue strength	44	67	72	.12	.10	.06	.71
Delayed pharyngeal swallow	37	63	53	.12	.06	.26	.32
Slowed/delayed vestibule closure	26	68	63	**.013**	.01	.02	.71
Reduced tongue control	37	47	32	.42	.16	.71	.26
Reduced A-P tongue movement	47	47	58	.51	.99	.41	.16
Reduced laryngeal elevation	5	21	26	.16	.08	.10	.65
Reduced tongue stabilization	28	17	17	.45	.32	.32	.99
Bilateral pharyngeal weakness	5	32	32	.06	.03	.03	.99
Reduced cricopharyngeal opening	0	21	16	.11	No test	No test	.65
Visible cricopharyngeal bar	5	21	5	.22	.18	.99	.18
Incomplete laryngeal vestibule closure	0	11	11	.37	No test	No test	.99
Other measures of swallowing							
Functional swallow	95	74	84	.14	.05	.32	.32
% Oral intake <50%	5	32	11	**.015**	.025	.32	.046
% Normal diet	84	53	58	**.045**	.034	.025	.71
Mean saliva weight (in grams)	5.31	0.65	0.93	**<.0001**	**<.0001**	**<.0001**	.16
SEM	0.52	0.08	0.18				

Abbreviations: SEM, standard error of the mean; A-P, anterior-posterior.

Note: Bolded values indicate $p < .05$ for overall test or $p < .017$ for pairwise test. ("No test" means frequencies were too low to perform statistical tests).