ORIGINAL ARTICLE

Functional Results of Primary Closure vs Flaps in Oropharyngeal Reconstruction

A Prospective Study of Speech and Swallowing

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Background: The preservation of speech and swallowing function is the primary goal when reconstructing soft tissue defects in the oral cavity or oropharynx. The type of reconstructive procedure used should be based on outcome data examining speech and swallowing function; yet, there is a paucity of such information.

Objectives: To present the results of a multi-institutional prospective study of speech and swallowing function before and after soft tissue reconstruction of the oral cavity and oropharynx, and to compare 3 methods of reconstruction with respect to speech and swallowing function: primary closure, distal myocutaneous flap, and microvascular free flap.

Design: Prospective case-comparison study.

Setting: Four leading head and neck cancer institutions.

Patients: The patients were selected from a database of 284 patients treated at the different institutions. The patients were matched for the location of the oral cavity or oropharyngeal defect and the percentage of oral tongue and tongue base resection. Those patients who had previous speech and swallowing deficits and patients in whom postoperative fistulas or wound infections developed were excluded from the study.

Methods: The patients underwent speech and swallowing evaluation preoperatively and 3 months after healing. This evaluation included videofluoroscopic studies of swallowing and tests of speech intelligibility and sentence articulation. Videofluoroscopy provided measures of swallowing efficiency and bolus movement. Liquid and paste consistencies were used in evaluating swallowing function.

Main Outcome Measure: The functional results of the reconstruction.

Results: Patients who had primary closure were more efficient at swallowing liquids, had less pharyngeal residue, a longer oral transit time with paste, and higher conversational intelligibility than patients who underwent reconstruction with a distal flap. Compared with patients who underwent reconstruction with a free flap, those who had primary closure had more efficient swallowing of liquids, less pharyngeal residue, and shorter pharyngeal delay times with paste. No difference in the speech and swallowing function existed between patients treated with distal myocutaneous flaps and those treated with microvascular free flaps.

Conclusion: Contrary to the current theory of oral and oropharyngeal reconstruction, we found that the use of primary closure resulted in equal or better function than the use of flap reconstruction in patients with a comparable locus of resection and percentage of oral tongue and tongue base resection.

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WHEN A surgeon is faced with the decision of how to reconstruct a soft tissue defect of the oral cavity or oropharynx (or both), the preservation of the speech and swallowing function is a primary consideration. Outcome data on which to base this decision are absent, however. We present the results of a multi-institutional prospective study that evaluated the speech and swallowing outcomes of patients having soft tissue reconstruction of the oral cavity, oropharynx, or both. The major factors that affect functional outcomes are the site and extent of resection and the type of reconstruction. To assess only the effects of reconstruction on function, the site and extent of resection must be controlled as carefully as posible.

A pilot study[1] of the surgical variables affecting postoperative swallowing efficiency established the critical importance of the tongue. As the percentage of resection of the oral tongue and tongue

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PATIENTS AND METHODS

SELECTION OF PARTICIPATING INSTITUTIONS

The institutions were selected based on the type of reconstructive methods used at the institution, the number of cases of head and neck cancer treated, the skill and experience of the surgeons, and the availability of speech and swallowing services. We found in some cases that an institution may have excellent reconstruction teams but does not have the speech and swallowing team to fulfill the outcome testing required for the study. Patients in this report were treated at the following institutions: Moffitt Cancer Center, Tampa, Fla; Northwestern University, Evanston, Ill; Roswell Park Cancer Institute, Buffalo, NY; University of Pittsburgh, Pittsburgh, Pa; University of Michigan, Ann Arbor; and Washington University, St Louis, Mo.

PATIENTS

Three sets of patient pairs were analyzed for this study. A set of 9 patients who had primary closure was matched with 9 patients receiving distal-flap reconstruction. Similarly, 9 patients who had primary closure were matched with 9 patients receiving free-flap reconstruction. Finally, 9 patients receiving distal-flap reconstruction were matched with 9 patients who had closure with free flaps. This information is summarized in **Table 1**, **Table 2**, and **Table 3**. All patients were between the ages of 21 and 80 years and had sufficient English-language skills to understand the consent form, articulation test, and study directions. No patient was included who had a neurologic disorder that affects speech or swallowing before the treatment of cancer. Patients who had previous radiotherapy to the head and neck or in whom a fistula or wound infection developed in the postoperative period were not included. Informed consent was obtained from patients and their families, as appropriate. This was done in accordance with the guidelines specified by the Institutional Review Board of Northwestern University and by the Institutional Review Board at each participating institution.

Patients were matched on the percentage (±5%) of oral tongue resected, percentage (±10%) of tongue base resected, and whether they received postoperative radiotherapy. Matched pairs were obtained within 4 major resection categories: (1) anterior tongue with floor of mouth resected with mandibular alignment preserved, (2) anterior tongue with floor of mouth resected with lateral segmental mandibular resection, (3) tonsil with more than 1 cm of tongue base resected plus or minus some soft palate with the mandibular alignment preserved, and (4) tonsil with more than 1 cm of tongue base resected plus or minus some soft palate with lateral segmental mandibular resection. "Lateral segmental mandibular resection" was defined as resection of the mandible lateral to the mental foramen.

Diagrams, operative reports, and data sheets completed by the operating surgeons were used for grouping the patients. At the time of the surgical procedure, diagrams of the resection were made by the surgeons, and measures of the flap's dimensions were also recorded. The resection dimensions were the length, width, and thickness. One of us (F.M.S.M.) determined the grouping of patients based on these data.

DATA COLLECTION

Data were collected at pretreatment and at 3 months after healing. The speech evaluation included conversational speech intelligibility and a sentence-articulation test to identify correct and incorrect consonant articulations. Conversational speech intelligibility was evaluated by the speech-language pathologists' recording of a 6- to 7-minute conversational speech sample from the patient according to methods described elsewhere.[2] The articulation test was a standard clinical procedure using the Fisher-Logemann Test of Articulation Competence.[3] The percentage of target consonant phonemes perceived as

base increased, the efficiency of oropharyngeal swallowing decreased. The extent of resection of the other oral structures or lateral mandible did not correlate with swallowing efficiency. Using this information, patients with different reconstruction types were matched based on the percentage of oral tongue and tongue base resected. The patients were drawn from a database of 284 patients accrued from 1985 to 1995, from different leading head and neck treatment centers. Only a multi-institutional database can acquire the number of patients to make such a comparison possible. With the extent of oral tongue and tongue base resection controlled, the effects of reconstruction can be evaluated. We describe the speech and swallowing outcomes of surgically treated patients with oral and oropharyngeal cancer who underwent reconstruction with primary closure, distal flaps, and free flaps.

RESULTS

The data analyzed were measured at 3 months after healing using preoperative data as a covariant to control for individual differences before the surgical procedure. **Table 4** contains the results for 9 patients with primary closure matched with 9 patients who received distal-flap reconstruction. The patients with distal-flap reconstruction had significantly lower OPSE on liquid boluses and significantly lower conversational intelligibility than did patients with primary closure. The patients who underwent reconstruction with distal flaps did have significantly faster oral transit times with paste boluses, but also had significantly more pharyngeal residue. These results may explain why OPSE with paste boluses was not significantly different between the group having primary closure and that having distal-flap closure.

Table 5 shows the results of 9 patients with primary closure matched with 9 patients who had a free-flap reconstruction. The patients with free-flap reconstruction had significantly lower OPSE with liquid boluses, significantly longer pharyngeal delay times with paste boluses, and lower conversational intelligibility (P=.15) than did patients with primary closure. As with the distal-flap group, the free-flap group had

correct by the clinician was computed and used for statistical analyses.

Swallowing functional outcomes were based on the videofluoroscopic evaluation performed preoperatively and 3 months after healing. A modified barium swallow, as described by Logemann et al,[4] was used with each patient trying to complete 2 swallows each of 1 mL of liquid and 1 mL of paste (Esophatrast or barium sulfate). These consistencies were selected because many patients with oral cancer have difficulty with 1 consistency or another, in various patterns. Not all patients were able to manage all the swallowing tasks. The swallows were recorded on videotape so that frame-by-frame and slow-motion analyses of temporal bolus movement could be done. The times of key swallowing events were identified, noting the approximate amount and location of any residue remaining in the oral cavity or pharynx and the amount and timing of aspiration.

From these observations and temporal data, the following measurements were made:

- *Oral transit time:* the time it takes a bolus to move through the oral cavity, measured from the onset of bolus transit until the head (leading edge) of the bolus passes the point where the ramus of the mandible crosses the tongue base;
- *Pharyngeal transit time:* the time required for a bolus to move through the pharynx, measured from the time when the head of the bolus passes the point where the ramus of the mandible crosses the tongue base until the tail of the bolus leaves the cricopharyngeal region;
- *Pharyngeal delay time:* the time required to initiate a pharyngeal swallow, measured from the time the head of the bolus passes the ramus of the mandible until the onset of laryngeal elevation;
- *Duration of laryngeal closure:* the length of time the laryngeal entrance between the arytenoid and base of epiglottis is closed during the swallow;
- *Duration of cricopharyngeal opening:* the length of time the cricopharyngeal region is open during the swallow;
- *Oropharyngeal swallowing efficiency* (OPSE): the approximate percentage of the bolus swallowed divided by the total transit time. The OPSE is a global measure that describes the interaction of the speed of movement of the bolus and the safety and efficiency of the mechanism in clearing material from the oropharynx while preventing aspiration.[5-7] The approximate percentage swallowed is a clinical judgment based on the proportion of the bolus passing through the cricopharyngeus vs that remaining in the oropharynx. The higher the OPSE, the better the swallowing function. This index is a convenient measure for comparing various clinical populations that may have different aspects of the oropharyngeal swallow impaired.[7]

STATISTICAL ANALYSES

Statistical analyses were conducted to assess the effect of closure type on speech and swallowing measures. To adjust for any preoperative differences, each patient's preoperative study was used as a covariate in the analysis of the data. For the swallowing measures, a mixed-model analysis of covariance was performed using closure type, bolus consistency, and the interaction of closure type and bolus consistency as fixed effects and the patient's preoperative swallowing measurement as a covariate. The pair and each patient within a pair were treated as random effects. For speech measures, an analysis of covariance was performed using closure type as the fixed effect and the patient's preoperative speech function as the covariate, with the pair as a random effect. When a significant interaction between the closure type and consistency was found for a swallowing measure, comparisons between the closure types were made for the liquid and the paste bolus separately. If no interaction was found, then a test of the main effect of the closure type was performed. Results are reported as mean±SE. The PROC MIXED procedure in commercially available statistical software was used for the statistical analyses.[8] The PROC MED procedure can be used for a variety of analyses including the analysis of covariance used in this study.

significantly more pharyngeal residue compared with patients with primary closure, indicating the need for additional clearing swallows.

Table 6 shows the results of distal-flap vs free-flap closures. There were no significant differences in the OPSE scores, delay of swallowing, measures of speech intelligibility, or consonant articulation between the 2 groups. The only significant difference was that the distal-flap group had significantly more oral residue than did the free-flap group.

Table 7 shows the ratio of flap volume to the resection volume for the distal- and free-flap groups. A ratio of less than 1 means that the flap was smaller than the defect it was used to reconstruct. Both the distal-flap and free-flap groups had ratios of less than 1.

COMMENT

The current rationale for oropharyngeal soft tissue reconstruction is to maintain the mobility of the remaining tongue. A number of authors have proposed this rationale.[1,4,9,10] In a pilot study[1] of the surgical variables affecting postoperative swallowing efficiency, the critical importance of the oral tongue and the tongue base was demonstrated. When the percentage of the resection of the oral tongue and the tongue base increased, the swallow efficiency (OPSE) decreased. It is the current practice to restore oral and pharyngeal lining with a flap to replace the resected tissue so that the remaining functional tongue will not be "tied down." This rationale does have some basis. In 1987, McConnel et al[9] conducted a retrospective pilot study of 20 patients receiving skin grafts, distal flaps, and tongue flaps. This study evaluated articulation and intelligibility, tongue mobility, and the patient's perception of swallowing. The tongue flaps gave the least favorable results. Logemann and Bytell[11] showed better transit times in patients who had no tongue used in the surgical closure than in patients with tongue-flap closure. Both of these study results could be anticipated because a tongue flap ties the remaining tongue down. The use of distal tissue as a skin muscle flap or free microvascular skin flap would seem reasonable to

Table 1. Nine Matched Pairs of Patients for Comparison of Primary Closure (PC) and Distal-Flap (DF) Reconstruction*

Pair No.	Locus of Resection Code†	Closure Type	% Resected		Postoperative Radiation Dose, Gy
			Oral Tongue	Tongue Base	
1	1	PC	20	0	0
		DF	20	0	0
2	1	PC	5	0	0
		DF	10	0	0
3	1	PC	10	0	61.2
		DF	15	0	60.0
4	1	PC	0	0	0
		DF	0	0	0
5	3	PC	5	0	64.0
		DF	0	0	50.4
6	3	PC	5	5	60.0
		DF	5	5	54.0
7	3	PC	5	5	0
		DF	0	0	0
8	4	PC	10	10	60.0
		DF	5	10	59.4
9	4	PC	8	25	60.0
		DF	10	30	60.0

*Patient pairs are matched on general locus of resection, percentage of oral tongue resected, percentage of tongue base resected, and postoperative radiotherapy status.

†Locus of resection codes are as follows: 1 indicates anterior tongue plus floor of mouth resection with mandibular alignment preserved; 3, tonsil with more than 1 cm of tongue base resection with or without some soft palate with mandibular alignment preserved; and, 4, tonsil with more than 1 cm of tongue base resection with or without some soft palate with lateral segmental mandibular resection.

Table 2. Nine Matched Pairs of Patients for Comparison of Primary Closure (PC) and Free-Flap (FF) Reconstruction*

Pair No.	Locus of Resection Code†	Closure Type	% Resected		Postoperative Radiation Dose, Gy
			Oral Tongue	Tongue Base	
1	1	PC	10	0	0
		FF	15	0	0
2	1	PC	10	0	61.2
		FF	10	0	64.0
3	2	PC	0	0	0
		FF	0	0	0
4	3	PC	25	30	60.0
		FF	30	50	64.0
5	3	PC	5	5	0
		FF	0	0	0
6	3	PC	0	60	63.0
		FF	0	50	66.0
7	4	PC	10	10	60.0
		FF	5	0	55.8
8	4	PC	8	25	60.0
		FF	5	25	54.4
9	4	PC	10	5	0
		FF	10	0	0

*The matching of patient pairs is described in the "Patients and Methods" section and in Table 1.

†Locus of resection codes are as follows: 1 indicates anterior tongue plus floor of mouth resection with mandibular alignment preserved; 2, anterior tongue plus floor of mouth resection with lateral segmental mandibular resection; 3, tonsil with more than 1 cm of tongue base resection with or without some soft palate with mandibular alignment preserved; and, 4, tonsil with more than 1 cm of tongue base resection with or without some soft palate with lateral segmental mandibular resection.

Table 3. Nine Matched Pairs of Patients for Comparison of Distal-Flap (DF) Reconstruction and Free-Flap (FF) Reconstruction*

Pair No.	Locus of Resection Code†	Closure Type	% Resected		Postoperative Radiation Dose, Gy
			Oral Tongue	Tongue Base	
1	1	DF	20	0	0
		FF	15	0	0
2	1	DF	15	0	60.0
		FF	10	0	64.0
3	1	DF	0	0	55.8
		FF	0	0	59.0
4	1	DF	15	0	60.0
		FF	20	0	58.0
5	1	DF	0	0	50.0
		FF	0	0	60.0
6	3	DF	0	0	0
		FF	0	0	0
7	4	DF	0	0	60.0
		FF	5	0	55.8
8	4	DF	10	30	60.0
		FF	5	25	54.0
9	4	DF	15	5	0
		FF	10	0	0

*The matching of patient pairs is described in the "Patients and Methods" section and in Table 1.

†A description of the locus of resection codes is given in the second footnote to Table 1.

prevent the tied-down tongue and to preserve tongue mobility. The results of this present study of patients with relatively small resections of the oral tongue (<30%) and tongue base (<60%) show no significant improvement in swallowing efficiency (OPSE) between patients having flaps and patients with primary closure (Tables 4 and 5). In fact, the patients with primary closure had better OPSE results on liquid swallows than did either of the patient groups with flaps.

Tongue mobility is also considered an important component in maintaining speech articulation. In this study, patients with primary closure obtained significantly better scores on speech intelligibility and better, although not significantly different, consonant articulation scores (P=.09) than patients with distal-flap closure. Patients with primary closure had better mean speech intelligibility scores than patients with free flaps, although this result was not statistically different (P=.15). The groups did not differ in consonant articulation scores.

These swallowing and speech outcome results do not support the theory that skin flaps or skin muscle flaps, whether free or distal, enhance function. In fact, these flaps appear to impair function in the soft tissue reconstruction of the oral cavity and oropharynx. Is there something about the nature of the flap itself that impairs function? In the 1987 study by McConnel et al,[9] skin grafts gave better functional results than distal flaps. Sessions et al[12] also found that skin grafts yielded better functional results. With these findings, the bulk of a muscle skin flap might be considered as a factor interfering with

Table 4. Results for 9 Patients With Primary Closure and 9 Patients With Distal-Flap Closure Matched on Resection Type, Percentage of Oral Tongue Resected and Tongue Base Resected, and Postoperative Radiotherapy Status*

Variable	Bolus Type	Primary Closure	Distal-Flap Closure	*P*
Oral transit time, s†	Liquid	0.14 ± 0.72	0.54 ± 0.77	.71
	Paste	4.50 ± .073	2.07 ± 0.76	.02‡
Pharyngeal transit time, s		0.96 ± 0.27	1.31 ± 0.28	.26
Oropharyngeal swallow efficiency†	Liquid	79.9 ± 8.2	50.9 ± 8.7	.01‡
	Paste	20.8 ± 8.1	31.8 ± 8.7	.33
Laryngeal closure duration, s	. . .	0.60 ± 0.08	0.49 ± 0.08	.35
Cricopharyngeal opening duration, s	. . .	0.41 ± 0.04	0.39 ± 0.04	.77
Pharyngeal delay time, s	. . .	0.11 ± 0.07	0.20 ± 0.08	.42
Oral residue, %	. . .	19.1 ± 6.5	27.9 ± 6.9	.36
Pharyngeal residue, %	. . .	6.8 ± 3.6	16.0 ± 3.8	.02‡
Speech intelligibility, %	. . .	90.0 ± 7.3	52.0 ± 6.1	.01‡
Correct consonant phonemes, %	. . .	75.0 ± 6.4	58.0 ± 6.4	.09

**Data are given as mean ± SE. Ellipses indicate that there was no significant interaction between closure type and bolus consistency, therefore liquid and paste swallows were pooled together.*
†Significant closure type by bolus consistency interaction.
‡Significant at P<*.05.*

Table 5. Results for 9 Patients With Primary Closure and 9 Patients With Free-Flap Reconstruction Matched on Resection Type, Percentage of Oral Tongue Resected and Tongue Base Resected, and Postoperative Radiotherapy Status*

Variable	Bolus Type	Primary Closure	Distal-Flap Closure	*P*
Oral transit time, s	. . .	1.31 ± 0.41	1.37 ± 0.43	.92
Pharyngeal transit time, s	. . .	1.04 ± 0.67	2.41 ± 0.64	.15
Oropharyngeal swallow efficiency†	Liquid	65.1 ± 7.8	35.6 ± 7.7	<.001‡
	Paste	16.4 ± 8.5	15.0 ± 8.4	.86
Laryngeal closure duration, s	. . .	0.63 ± 0.21	0.43 ± 0.21	.47
Cricopharyngeal opening duration, s	. . .	0.40 ± 0.05	0.40 ± 0.05	.98
Pharyngeal delay time, s†	Liquid	0.46 ± 0.62	–0.04 ± 0.65	.60
	Paste	–0.07 ± 0.65	2.55 ± 0.71	.01‡
Oral residue, %	. . .	27.5 ± 6.1	21.5 ± 6.4	.25
Pharyngeal residue, %	. . .	7.5 ± 5.6	27.5 ± 5.8	.02‡
Speech intelligibility	. . .	72.0 ± 6.6	55.0 ± 7.5	.15
Correct consonant phonemes, %	. . .	59.0 ± 8.3	49.0 ± 8.8	.47

**Data are given as mean ± SE. Ellipses indicate that there was no significant interaction between closure type and bolus consistency, therefore liquid and paste swallows were pooled together.*
†Significant closure type by bolus consistency interaction.
‡Significant at P<*.05.*

Table 6. Results for 9 Patients With Distal-Flap Closure and 9 Patients With Free-Flap Reconstruction Matched on Resection Type, Percentage of Oral Tongue Resected and Tongue Base Resected, and Postoperative Radiotherapy Status*

Variable	Distal-Flap Closure	Free-Flap Closure	*P*
Oral transit time, s	1.26 ± 0.22	0.77 ± 0.21	.10
Pharyngeal transit time, s	1.29 ± 0.22	1.22 ± 0.22	.82
Oropharyngeal swallow efficiency	39.6 ± 7.3	46.59 ± 6.73	.45
Laryngeal closure duration, s	0.45 ± 0.12	0.47 ± 0.11	.86
Cricopharyngeal opening duration, s	0.35 ± 0.05	0.40 ± 0.05	.41
Pharyngeal delay time, s	0.48 ± 0.18	0.39 ± 0.17	.71
Oral residue, %	30.3 ± 5.2	11.0 ± 5.1	.008†
Pharyngeal residue, %	11.1 ± 5.4	19.4 ± 5.3	.28
Speech intelligibility, %	48.0 ± 11.4	49.0 ± 11.3	.94
Correct consonant phonemes, %	49.0 ± 9.4	59.0 ± 9.4	.47

**Data are given as mean ± SE.*
†Significant at P<*.05.*

Table 7. Mean (± SE) for Volume Resected, Flap Volume, and Ratio of Flap Volume to Volume Resected for Distal- and Free-Flap Reconstructions

Group	Volume Resected, cc	Flap Volume, cc	Ratio
Distal flap (n = 14)	211.6 (± 68.1)	113.5 (± 22.6)	0.867 (± 0.284)
Free flap (n = 12)	136.0 (± 54.9)	43.7 (± 8.4)*	0.743 (± 0.225)*

**Nine patients.*

function in the oral cavity and oropharyngeal reconstruction. One of the rationales for using microvascular free flaps is to decrease the bulk as compared with distal myocutaneous flaps. In Table 7, however, the ratio of flap volume to volume resected showed the flaps to be smaller than the defects they filled. If bulk is defined as the flap volume being larger than the tissue volume resected, then excess bulk is not occurring in the patients in this study.

The oropharyngeal swallowing mechanism can be conceptualized as a pump, with the tongue being the piston and the pharynx being the dynamic chamber. This is the model used in manofluorographic studies.[13] In this model, a flap could be acting as an adynamic segment that impairs the driving force of the remaining tongue, thereby reducing the swallowing efficiency. This flap may also reduce the fine control of the tongue for speech.

CONCLUSIONS

These results challenge the current theories of oral and oropharyngeal reconstruction that advocate the replacement of resected soft tissue in the oral cavity or oropharynx with skin or skin muscle flaps to preserve the speech and swallowing functions. In this study of patients with small resections of the oral tongue and tongue base, primary defect closure gave equal or better functional results than either flap reconstruction, and no difference existed between distal-flap and free-flap closure. We continue to compile patients from multiple institutions so that we can compare the type of closure used to reconstruct larger defects of the oral tongue and tongue base.

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REFERENCES

1. McConnel FMS, Logemann JA, Rademaker AW, et al. Surgical variables affecting postoperative swallowing efficiency in oral cancer patients: a pilot study. *Laryngoscope.* 1994;104:87-90.
2. Pauloski BR, Logemann JA, Rademaker AW, et al. Speech and swallowing function after anterior tongue and floor of mouth resection with distal flap reconstruction. *J Speech Hear Res.* 1993;36:267-276.
3. Fisher HB, Logemann JA. *The Fisher-Logemann Test of Articulation Competence.* Boston, Mass: Houghton Mifflin Co; 1971.
4. Logemann JA, Pauloski BR, Rademaker AW, et al. Speech and swallow function after tonsil/base of tongue resection with primary closure. *J Speech Hear Res.* 1993;36:918-926.
5. Logemann JA. Swallow physiology and pathophysiology. *Otolaryngol Clin North Am.* 1988;21:613-623.
6. Logemann JA, Kahrilas PJ, Kobara M, Vakil NB. Benefit of head rotation on pharyngoesophageal dysphagia. *Arch Phys Med Rehabil.* 1989;70:767-771.
7. Rademaker AW, Pauloski BR, Logemann JA, Shanahan TK. Oropharyngeal swallow efficiency as a representative measure of swallow function. *J Speech Hear Res.* 1994;37:314-320.
8. SAS Institute Inc. *SAS/STAT Software: Changes and Enhancement for Release 6.12.* Cary, NC: SAS Institute Inc; 1996.
9. McConnel FMS, Teichgraeber JF, Alder RK. A comparison of three methods of oral reconstruction. *Arch Otolaryngol Head Neck Surg.* 1987;113:496-500.
10. Schramm VL, Johnson JT, Myers EN. Skin grafts and flaps in oral cavity reconstruction. *Arch Otolaryngol.* 1983;109:175-177.
11. Logemann JA, Bytell DE. Swallowing disorders in three types of head and neck surgical patients. *Cancer.* 1979;81:469-478.
12. Sessions D, Zill R, Schwartz S. Deglutition after conservative surgery for cancer of the larynx and pharynx. *Otolaryngol Head Neck Surg.* 1979;87:779-796.
13. McConnel FMS, Cerenko D, Jackson RT. Clinical application of the manofluorogram. *Laryngosope.* 1988;98:705-711.