Int J Clin Oncol (2005) 10:229–233
DOI 10.1007/s10147-005-0500-2

REVIEW ARTICLE

Yoshihiro Kimata · Minoru Sakuraba · Yuzaburo Namba
Ryuichi Hayashi · Satoshi Ebihara

Functional reconstruction with free flaps following ablation of oropharyngeal cancer

Received: April 25, 2005

Abstract With the development of various reconstructive procedures, most patients who have undergone ablative surgery for oropharyngeal cancer have obtained satisfactory functional results and good quality of life. However, many questions remain concerning methods of obtaining optimal postoperative oral and pharyngeal functions, especially after glossectomy. This review focuses on reconstructive methods after partial glossectomy, hemiglossectomy, and subtotal or total glossectomy and discusses current problems and the possibility of sensory and dynamic reconstruction.

Key words Reconstruction after glossectomy · Postoperative functions · Microsurgical reconstruction

Introduction

The ultimate purpose of reconstruction is to duplicate the form and function of normal anatomic structures. The goals of oropharyngeal reconstruction from the 1970s to the early 1980s were to close the oral cavity and to avoid local postoperative complications. Several reconstructive methods employing microsurgical techniques were introduced to achieve these goals. However, the goals of reconstruction have now changed to maintaining postoperative function and improving quality of life.

In this field, functional reconstruction after glossectomy is the most challenging area; however, postoperative functional results are often unstable, and additional laryngectomy may be required because of intractable aspiration and pneumonia. In this review, we discuss reconstructive methods after partial glossectomy, hemiglossectomy, and subtotal or total glossectomy; we also discuss the possibility of dynamic and sensory reconstruction and current problems.

Y. Kimata (✉) · Y. Namba
Department of Plastic and Reconstructive Surgery, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, 2-5-1 Shikatacho, Okayama 700-8558, Japan
Tel. +81-86-235-7212; Fax +81-86-235-7210
e-mail: ykimata@cc.okayama-u.ac.jp

M. Sakuraba · R. Hayashi · S. Ebihara
Division of Plastic and Reconstructive Surgery and of Head and Neck Surgery, National Cancer Center Hospital East, Chiba, Japan

History of reconstructive methods after glossectomy

Resection of the intrinsic and extrinsic musculature of the tongue prevents active intraoral food transposition and inhibits articulation. Loss of the mylohyoid sling removes the support of the floor of the mouth and prevents elevation of the base of the tongue, affecting speech and swallowing functions. Reconstruction immediately after glossectomy involves three aspects: restoration of the mucosal surface to preserve the movement of the residual tongue, restoration of coordinated motor activity, and restoration of sensation. Early attempts at reconstruction after glossectomy aimed only to resurface the defect with skin grafts, local mucosal flaps, and, later skin flaps, such as the deltopectoral skin flap.[1–3] Because these flaps were of insufficient bulk, reconstruction with them resulted in dead space, pooling of secretions, and high rates of local complications. Because of these poor results, radiotherapy was often selected as an alternative treatment until the 1970s.[4] After the pectoralis major myocutaneous flap was introduced to head and neck reconstruction by Ariyan[5] and Baek et al.[6] in 1979, both wider surgical resection and satisfactory postoperative functions became possible. The bulk of the pectoralis major myocutaneous flap decreases the size of the oral cavity and fills the dead space. However, this flap has several disadvantages, including poor reliability of its cutaneous portion, limited pedicle length, and compromised tongue elevation due to the muscle's downward traction. To address these problems, the free flap with microsurgical anastomosis was introduced to head and neck reconstruction in the early 1980s. Flaps often used for reconstruction include the free radial forearm flap,[7] the rectus abdominis musculocutane-

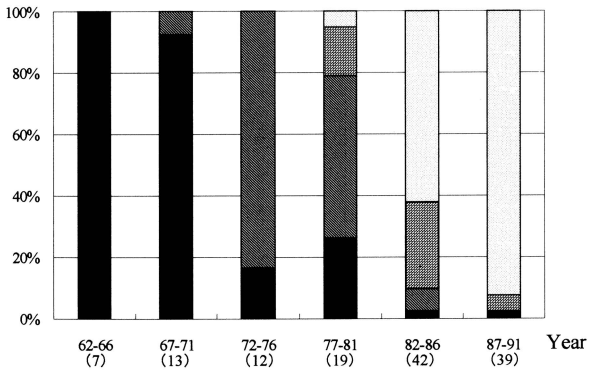

Fig. 1. Changes in the reconstructive methods used for massive oropharyngeal defects at the National Cancer Center Hospital, Japan, from 1962 to 1991. The numbers of patients with massive oropharyngeal defects are shown in *parentheses*. *Pale gray bars*, free flap; *stippled bars*, pedicled myocutaneous flap; *striped bars*, pedicled cutaneous flap; *black bars*, without reconstruction

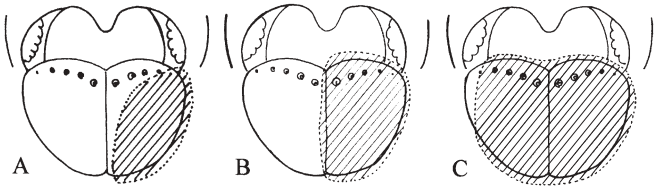

Fig. 2A–C. Classification of glossectomy defects. **A** shows partial glossectomy, in which the defect involves less than half of the mobile tongue and resection of the tongue base is minimal. **B** shows hemiglossectomy, which involves resection of half of the mobile tongue and tongue base. **C** shows subtotal or total glossectomy, in which more than two-thirds of the mobile tongue and the tongue base are removed

ous flap,[8] the latissimus dorsi musculocutaneous flap,[9] the scapular flap,[10] and the jejunal flap,[11] all of which are easily elevated and have long vascular pedicles. In the early 1990s, the use of microsurgical techniques and free flaps for head and neck reconstruction became widespread (Fig. 1). For the reconstruction of large, complex defects of the head and neck, the anterolateral thigh flap has been suggested by several authors.[12–14] The main advantage of this flap is the possibility of combined transfer with other flaps, allowing a variety of large defects of the head and neck to be repaired.

Morbidity at the flap donor site remains a concern. To minimize donor-site morbidity, perforator flaps, which are skin flaps without harvested muscle, were developed to reconstruct head and neck defects. The deep inferior epigastric artery perforator flap is the most commonly used flap of this type.[15] The classic free groin flap has also been used to minimize donor-site morbidity in head and neck reconstruction.[16]

Although several reconstructive methods and flaps have been developed since the 1970s, several important points should be kept in mind, such as minimizing early postoperative complications that may prolong hospitalization and become life-threatening, maintaining postoperative functions, and decreasing the degrees of surgical invasiveness and donor-site morbidity. To shorten operative time, the preferred flap is one that can be elevated simultaneously with tumor resection while the patient remains in the supine position.

Classification of defects after glossectomy

We have classified defects after glossectomy into three types: those after partial glossectomy, hemiglossectomy, and subtotal or total glossectomy (Fig. 2). In partial glossectomy the defect involves less than half of the mobile tongue, and resection of the tongue base is minimal. Hemiglossectomy resects half the tongue base and half the mobile tongue. In subtotal or total glossectomy more than two-thirds of the mobile tongue and the tongue base are removed.

Partial glossectomy defects

In most patients with partial glossectomy, primary closure is possible with minimal disturbance of speech and swallowing functions. When a wide defect of the mucosa of the floor of the mouth remains after primary closure from the tip of the residual tongue, transfer of a split-thickness skin graft is the most adaptable and simple procedure. The degree of redundancy can best be gauged by distracting the tongue and tailoring the graft to the defect that has been stretched to its maximum dimensions.[17] Local mucosal flaps, such as the buccal mucosal flap and the facial artery musculomucosal flap,[18] are also effective for preventing local contracture. For filling submandibular dead space, local flaps, such as the digastric muscle flap[19] and the sternocleidomastoid flap, are useful.

Hemiglossectomy defects

Resection of half of the mobile tongue and tongue base produces significant swallowing and speech dysfunction. Important points in the reconstruction of this type of defect are to preserve the mobility of the mobile tongue and to fill the dead space just below the mandible after tumor resection with the pull-through method. Because the total volume of dead space is moderate, a moderately sized flap should be selected and transferred. Possible choices include a radial forearm flap, an anterolateral thigh flap, an anteromedial thigh flap, a deep epigastric inferior artery perforator flap, and a groin flap. However, when the flap is sutured to the cut edges of the residual mobile tongue, the reconstructed tongue's movements are often inhibited by the weight of the flap and by contracture in the oral space. To resolve this problem, a bilobular radial forearm flap[20] has been suggested to preserve tongue mobility, by separating the reconstruction of the mobile tongue from the reconstruction of the floor of the mouth. Multilobular anterolateral thigh flaps[21] have also been developed for this

purpose, although speech function with these flaps has not been accurately evaluated. Our experiences of the past 25 years suggest that the mobile residual tongue should be closed primarily 3 to 4 cm from its tip to allow maximal movement and that the flap should be grafted to the defect of the floor of the mouth.

The pectoralis major myocutaneous flap is also another good choice for reconstruction after hemiglossectomy;[5,6] however, the flap cannot be elevated while the tumor is being resected, and the bulkiness of subcutaneous tissues in female patients can be a problem. With adequate reconstructive procedures after hemiglossectomy, functional results are satisfactory in most patients.

Subtotal or total glossectomy defects

The development of the microsurgical free-flap technique has greatly improved the quality of life of patients after subtotal or total glossectomy. We have achieved satisfactory results in reconstruction after subtotal and total glossectomy, with laryngeal preservation in 95.3% and 70% of patients, respectively.[22,23] However, some patients have poor speech and swallowing functions after surgery, despite laryngeal preservation. Considerable effort must be made to preserve the larynx;[24–27] however, functional results are often unstable, and the effectiveness of total glossectomy without laryngactomy remains questionable.[28]

To obtain satisfactory results in reconstruction after subtotal or total glossectomy, several important points must be considered, including: (1) the patient's preoperative condition, (2) structures resected in addition to the tongue, (3) the patient's age, (4) the bulk of the transferred flap, and (5) laryngeal suspension.

In a previous study, we found that patients with preoperative cerebral dysfunction or poor cardiovascular or pulmonary function were poor candidates for laryngeal preservation. Furthermore, we believe that laryngeal preservation will be of limited benefit if more than half of the oral and cervical tissues or the entire tongue and epiglottis have been resected. The postoperative function of unresected tissues is difficult to predict preoperatively, but it is negatively correlated with patient age. Postoperative function is generally poorer in patients older than 70 years.[23]

A transferred flap of sufficient bulk works together with the buccal, palatal, and neighboring pharyngeal muscles to produce positive oropharyngeal propulsion-pump forces. However, few studies[17,29,30] have examined the importance of the height of the reconstructed tongue for swallowing and articulation. In our recent study,[31] we classified the shape of the reconstructed tongue into four types – protuberant, semiprotuberant, flat, and depressed – and found that postoperative speech and swallowing functions were significantly worse in patients with flat or depressed tongues than in patients with semiprotuberant or protuberant tongues.

To help ensure that reconstructed tongues are protuberant, wider flaps, at least 1.5-cm-thick, should be used. Therefore, we prefer rectus abdominis musculocutaneous flaps, which can be elevated while the tumor is being resected with the patient in the supine position. Some authors[32] have suggested that, to ensure a reconstructed tongue of sufficient height, cutaneous flaps should be designed approximately 20% wider and longer than the defect. We now intend to design flaps 30% wider than the defect (i.e., 9 to 10 cm wide in Asian patients). However, problems still arise in patients who have lost a great deal of weight. For such patients, it may be necessary for several cutaneous flaps to be transferred to increase tissue volume (Fig. 3). Several authors have reported the use of pedicled pectoralis major myocutaneous flaps for reconstruction after total glossectomy.[33–35] However, in Asian patients, the reliable cutaneous portion of this flap does not fill the oral cavity, and neck contracture often develops postoperatively.

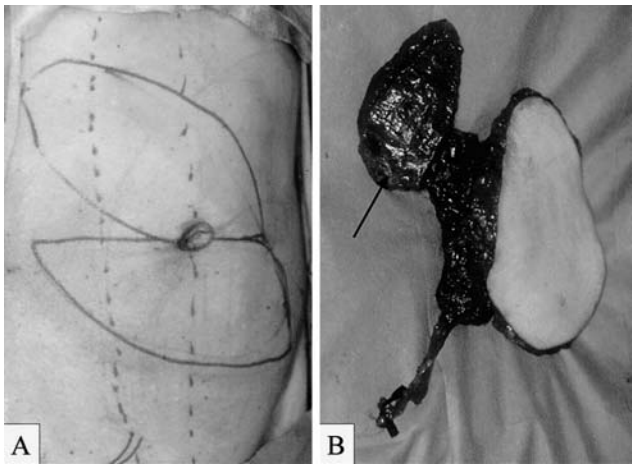

Fig. 3A,B. Rectus abdominis musculocutaneous flap in an extremely thin patient. **A** shows the design of the cutaneous portion of the flap. **B** shows the elevated flap; the cutaneous portion is de-epithelialized (*arrow*) and grafted under another cutaneous portion of the flap at the neck to reconstruct a tongue of sufficient volume

The effectiveness of laryngeal suspension has been discussed in several articles.[24,33,35] However, a cineradiographic study by Myers[36] has shown that neither the hyoid bone nor laryngeal elevation are essential for effective swallowing. Indeed, most of our patients could swallow without additional laryngeal suspension; however, in two of our patients, severe laryngeal prolapse occurred and caused the reconstructed tongue to be depressed. Therefore, to prevent prolapse of the transferred flap, we now use thick nylon sutures to suspend the larynx from the mandible (with approximately 2 cm between the superior border of the hyoid bone and the inferior border of the mandible).

To achieve a more functional reconstructed tongue

A fully functional tongue cannot be reconstructed with current methods, and the possibility of postoperative function is dependent on the extent of resection. However, to obtain better functional results, some ambitious reconstructive

procedures have been attempted. Mucosal sensation plays an important role in oral function and the patient's quality of life. The ability to sense ingested material in different parts of the mouth facilitates its presentation either to the teeth for chewing or to the tongue for swallowing. Intact intraoral sensation prevents the pooling of saliva and drooling that are frequently seen after extensive head and neck reconstruction. To restore sensation to the reconstructed tongue, David,[37] in 1977, first reported the use of the innervated deltopectoral cutaneous flap for intraoral reconstruction; he obtained good results in two of four patients. The free sensate dorsalis pedis flap and lateral arm flaps have also been used to restore intraoral sensation.[38,39] More recently, innervated radial forearm flaps have been the most commonly used for reconstruction after partial glossectomy.[40] In particular, Boyd et al.[41] have shown, with sophisticated sensory testing, that the innervated flap is superior to the noninnervated flap. We also examined the benefit of the sensory flap in patients in whom more than half of the tongue had been resected;[42] we found that postoperative sensory recovery was significantly better with innervated sensate anterolateral thigh or rectus abdominis muscle flaps than with noninnervated flaps. However, results of Semmes-Weinstein testing showed that recovery did not reach the level of protective sensation. Although additional objective and functional testing is required and the need for sensory reeducation should be considered, this simple operative procedure, using sensate flaps, can improve postoperative intraoral function and should be attempted after glossectomy when possible.

Reconstruction of a mobile tongue after glossectomy is the goal for the patient and for many reconstructive surgeons. However, tongue musculature is now most often reconstructed with nonfunctional, noncontractile tissues. Some attempts have been made to reconstruct the mobile tongue with a latissimus dorsi musculocutaneous flap or a rectus abdominis musculocutaneous flap in which the included motor nerves are coapted to the remaining hypoglossal nerve.[43,44] Although the effectiveness of these dynamic reconstructive methods after glossectomy has been reported, equally satisfactory results can be obtained with the methods we have described for use after subtotal or total glossectomy defects. Because the hypoglossal nerve includes many types of motor nerve fibers for intrinsic tongue muscles, whether a single transferred muscle can help to restore complicated swallowing functions is questionable. Ideally, three or more muscle-transfer procedures should be performed to reconstruct the mobile tongue. Reinnervating the transferred muscle by coapting its motor nerves to the hypoglossal nerve will help to decrease the degree of muscle atrophy and maintain the volume of the reconstructed tongue. Infrahyoid muscle flap transfer[45] and temporal muscle suspension[46] are other methods to increase the movement of the reconstructed tongue by exploiting the contractile force of neighboring muscles. Reconstructing a fully mobile tongue is extremely difficult with current methods; however, we remain motivated to develop surgical procedures to optimize the patient's quality of life.

Conclusion

In this review, we have described several reconstructive methods for obtaining good functional results after glossectomy. However, surgeons should always consider prognosis when selecting reconstructive methods for patients who have undergone glossectomy, because the survival rate of these patients is generally low. Important points that enable the selection of appropriate reconstructive methods are: minimizing early postoperative complications, maintaining postoperative functions, and decreasing surgical invasiveness and flap donor-site morbidity.

References

1. Edgerton MT, McKee DM (1959) Reconstruction with loss of the hyomandibular complex in excision of large cancers. Arch Surg 78:425–436
2. McGregor IA (1963) The temporal flap in intra-oral cancer: its use in repairing the postexcisional defect. Br J Plast Surg 16:318–335
3. Bakamjian VY, Long M, Rigg B (1971) Experience with the medially based deltopectoral flap in reconstructive surgery of the head and neck. Br J Plast Surg 24:174–183
4. Parson JT, Million RR, Cassisi NJ (1982) Carcinoma of the base of the tongue: results of radical irradiation with surgery reserved for irradiation failure. Laryngoscope 92:689–696
5. Ariyan S (1979) The pectoralis major myocutaneous flap: a versatile flap for reconstruction in the head and neck. Plast Reconstr Surg 63:73–81
6. Baek SM, Biller HF, Kriespi YP, et al. (1979) The pectoralis major myocutaneous island flap for reconstruction of the head and neck. Head Neck Surg 1:293–300
7. Souter DS, Scheker LR, Tanner NSB, et al. (1983) The radial forearm flap: a versatile method for intraoral reconstruction. Br J Plast Surg 36:1–8
8. Nakatsuka T, Harii K, Yamada A, et al. (1994) Versatility of a free inferior rectus abdominis flap for head and neck reconstruction: analysis of 200 cases. Plast Reconstr Surg 93:762–769
9. Sabatier RE, Bakamjian VY. (1985) Transaxillary latissimus dorsi flap reconstruction in head and neck cancer: limitations and refinements in 56 cases. Am J Surg 150:427–434
10. Swarts WM, Banis JC, Newton ED, et al. (1986) The osteocutaneous scapular flap for mandibular and maxillary reconstruction. Plast Reconstr Surg 77:530–545
11. Hester TR Jr, McConnel FMS, Nahai F, et al. (1980) Reconstruction of cervical esophagus, hypopharynx and oral cavity using free jejunal transfer. Am J Surg 140:487–491
12. Song YG, Chen GZ, Song YL (1984) The free thigh flap: a new free flap concept based on the septocutaneous artery. Br J Plast Surg 37:149–159
13. Koshima I, Fukuda S, Yamamoto H, et al. (1993) Free anterolateral thigh flaps for reconstruction of head and neck defects. Plast Reconstr Surg 92:421–420
14. Kimata Y, Uchiyama K, Ebihara S, et al. (1997) Versatility of the free anterolateral thigh flap for reconstruction of head and neck defects. Arch Otolaryngol Head Neck Surg 123:1325–1331
15. Beausang ES, Mckay D, Brown DH, et al. (2003) Deep inferior epigastric perforator flaps in head and neck reconstruction. Ann Plast Surg 51:561–563
16. Murakami R, Tanaka K, Kobayashi K, et al. (1998) Free groin flap for reconstruction of the tongue and oral floor. J Reconstr Microsurg 14:49–55
17. Urken ML, Moscoso JF, Lawson W, et al. (1994) A systematic approach to functional reconstruction of the oral cavity following partial and total glossectomy. Arch Otolaryngol Head Neck Surg 120:589–601

18. Pribaz J, Stephens W, Crespo L, et al. (1992) A new intraoral flap: facial artery musculomucosal (FAMM) flap. Plast Reconstr Surg 90:421–429
19. Mastuura K, Shiga K, Suzuki H, et al. (2003) Digastric muscle bipedicle flap used for oral floor reconstruction (in Japanese). Head and Neck Cancer 29:98–103
20. Urken ML, Biller HF (1994) A new design for the sensate radial forearm flap to preserve tongue mobility following significant glossectomy. Arch Otolaryngol Head Neck Surg 120:26–31
21. Koshima I, Hosoda M, Moriguchi T, et al. (2000) New multilobe "accordion" flaps for three-dimensional reconstruction of wide, full-thickness defects in the oral floor. Ann Plast Surg 45:187–192
22. Uchiyama K, Kimata Y, Ebihara S (1996) Functional evaluation after total or subtotal glossectomy. Presented at the 39th Annual Meeting of the Japan Society of Plastic and Reconstructive Surgery, Osaka, April 17, 1996
23. Kimata Y, Uchiyama K, Ebihara S, et al. (2000) Postoperative complications and functional results after total glossectomy with microvascular reconstruction. Plast Reconstr Surg 106:1028–1035
24. Calcaterra TC (1971) Laryngeal suspension after supraglottic laryngectomy. Arch Otolaryngol 94:306–309
25. Effron MZ, Johnson JT, Myers EN, et al. (1981) Advanced carcinoma of the tongue. Arch Otolaryngol 109:694–697
26. Myers EN (1972) The role of total glossectomy in the management of cancer of the oral cavity. Otolaryngol Clin North Am 5:343–355
27. Biller HF, Lawson W, Baek S-M (1983) Total glossectomy: a technique of reconstruction eliminating laryngectomy. Arch Otolaryngol 109:69–73
28. Gehanno P, Guedon C, Barry B, et al. (1992) Advanced carcinoma of the tongue: total glossectomy without total laryngectomy. Review of 80 cases. Laryngoscope 102:1369–1371
29. Hanghey BH, Fredrickson JM (1991) The latissimus dorsi donor site: current use in head and neck reconstruction. Arch Otolaryngol Head Neck Surg 117:1129–1134
30. Hirano M, Kuroiwa Y, Tanaka S, et al. (1992) Dysphagia following various degrees of surgical resection for oral cancer. Ann Otol Rhinol Laryngol 101:138–141
31. Kimata Y, Sakuraba M, Hishinuma, et al. (2003) Analysis of the relations between the shape of the reconstructed tongue and postoperative functions after subtotal or total glossectomy. Laryngoscope 113:905–909
32. Kiyokawa K, Tai Y, Inoue Y, et al. (1999) Functional reconstruction of swallowing and articulation after total glossectomy without laryngectomy: money pouch-like reconstruction method using rectus abdominis myocutaneous flap. Plast Reconstr Surg 104: 2015–2020
33. Sultan MR, Coleman JJ (1989) Oncologic and functional consideration of total glossectomy. Am J Surg 158:297–302
34. Weber RS, Ohlms L, Bowman J, et al. (1991) Functional results after total or near total glossectomy with laryngeal preservation. Arch Otolaryngol Head Neck Surg 117:512–515
35. Tiwari R, Karim ABMF, Greven AJ, et al. (1993) Total glossectomy with laryngeal preservation. Arch Otolaryngol Head Neck Surg 119:945–949
36. Myers EN (1972) The role of total glossectomy in the management of cancer of the oral cavity. Otolaryngol Clin North Am 5:343–355
37. David DJ (1977) Use of an innervated deltopectoral flap for intraoral reconstruction. Plast Reconstr Surg 60:377–380
38. Franklin JD, Withers EH, Madden JJJ, et al. (1979) Use of the free dorsalis pedis flap in head and neck repairs. Plast Reconstr Surg 63:195–204
39. Matloub HS, Larsen DL, Kuhn JC, et al. (1989) Lateral arm free flap in oral cavity reconstruction: a functional evaluation. Head Neck Surg 11:205–211
40. Urken ML, Weinberg H, Vickery C, et al. (1990) The neurofasciocutaneous radial forearm flap in head and neck reconstruction: a preliminary report. Laryngoscope 100:161–173
41. Boyd B, Mulholland S, Gullane P, et al. (1994) Reinnervation lateral antebrachial cutaneous neurosome flaps in oral reconstruction: are we making sense? Plast Reconstr Surg 93:1350–1359
42. Kimata Y, Uchiyama K, Ebihara S, et al. (1999) Comparison of innervated and noninnervated free flaps in oral reconstruction. Plast Reconstr Surg 104:1307–1313
43. Haughey BH (1993) Tongue reconstruction: concepts and practice. Laryngoscope 103:1132–1141
44. Yamamoto Y, Sugihara T, Furuta Y, et al. (1998) Functional reconstruction of the tongue and deglutition muscles following extensive resection of the tongue cancer. Plast Reconstr Surg 102:993–998
45. Remmert SM, Sommer KD, Majocco AM, et al. (1997) The neurovascular infrahyoid muscle flap: a new method for tongue reconstruction. Plast Reconstr Surg 99:613–618
46. Takeichi Y, Aoyama H, Suzuki K, et al. (2004) The video analysis of the temporal muscle dynamic suspension for oropharyngeal reconstructions (in Japanese). Head and Neck Cancer 30:85–93