considerable invasion or lengthy operating time. There have been many reports on the complications of free tissue transfers in the head and neck,[1–3,5–8] but few have analyzed the subsequent treatment for cases that have failed because of vascular thrombosis. In this article, we analyze our cases with total flap necrosis caused by vascular thrombosis in the head and neck and discuss the optimal treatment according to the defect type.

PATIENTS AND METHODS

A retrospective chart review of 502 patients who had undergone free flap transfer after cancer ablation in the head and neck between 1993 and May of 2005 at the University of Tokyo Hospital identified 19 patients (3.8 percent) with total necrosis of the transferred flap caused by arterial [13 of 19 (68 percent)] or venous [six of 19 (32 percent)] thrombosis. In our series, both immediate and secondary reconstructions were included. There were four women and 15 men ranging in age from 30 to 80 years, with an average of 58 years. Reconstruction was immediate in 10 and secondary in nine. The average follow-up was 20 months (range, 3 to 66 months). These 19 patients were divided into the following four groups for the sake of convenient analysis:

Group I (n = 4): Patients who underwent free jejunal transfer following pharyngoesophagectomy for hypopharyngeal cancer.
Group II (n = 7): Patients who underwent immediate reconstruction using a free flap other than the intestines.
Group III (n = 2): Patients who underwent secondary soft-tissue reconstruction with a free flap to improve a certain function.
Group IV (n = 6): Patients who underwent secondary bony reconstructions with free vascularized bone or osteocutaneous flap transfer.

The age of the patients, disease, methods of cancer resection, flap used in the initial reconstruction, and thrombosed vessels (artery or vein) are listed in Table 1.

The validity of the treatments at flap loss was assessed based on the following parameters:

Group I: Time required by the initiation of oral intake, and quality of diet.
Group II: Time required by the initiation of oral intake, quality of diet (swallow function), and speech.
Group III: Functional improvement.
Group IV: Success rate of flap survival, control of

Table 1. General Summary of the Four Groups

Group	Sex	No.	Average Age (yr)	Disease	No.	Method of Cancer Ablation	No.	Flap Used	No.	Thrombosed Vessel	No.
I	F	1	62–80	Hypopharyngeal cancer	4	Pharyngolaryngoesophagectomy	4	Jejunum	4	Artery	2 (3)*
	M	3	(71)							Vein	2
II	F	1	48–74	Lingual cancer	4	Total glossolaryngectomy	1	RAMC	3	Artery	6
	M	6	(60)	Buccal mucosal cancer	1	Subtotal glossectomy	2	ALT	2	Vein	1
				Oral floor cancer	2	Hemiglossectomy	1	Forearm	1		
						Marginal mandibulectomy	1	Upper arm	1		
						Local resection	2				
III	F	1	30, 56	Intraoral contracture	1			Forearm	1	Artery	1
	M	1		Facial palsy, fistula	1			LDMC	1	Vein	1
IV	F	2	42–58	Maxillary defect	4			Forearm plus scapular osteocutaneous	2	Artery	4
	M	4	(52)	Mandibular defect	2			Forearm with radius	1	Vein	2
								Scapular osteocutaneous	1		
								Iliac bone	1		
								Fibular osteocutaneous	1		
I–IV	F	4	30–80							Artery	13 (14)*
	M	15	(58)							Vein	6

RAMC, rectus abdominis musculocutaneous; ALT, anterolateral thigh; LDMC, latissimus dorsi musculocutaneous; M, male; F, female.
*Both the artery and vein were thrombosed in patient 2.

infection, aesthetic appearance, and smoothness of oral intake.

Statistical analysis was not performed because the sample sizes were small within the groups.

RESULTS

Patient summaries are listed in Tables 2 through 5.

Group I

In group I (Table 2), in two of four patients, another jejunal segment was harvested and transferred, and continuity of the esophagus was obtained successfully without leakage. Of these two patients, one commenced oral intake 10 days postoperatively and could eat normally, whereas in the other patient, the retransferred jejunum survived well without leakage but oral intake was started on postoperative day 50 because of serious cerebral infarction after the salvage operation. The patient had a soft diet.

In contrast, the other two patients underwent pharyngostoma and esophagostoma formation and coverage of the posterior wall of the pharyngoesophagus with a deltopectoral flap. Further reconstruction of the cervical esophagus was carried out with a pectoralis major musculocutaneous flap 63 days postoperatively in one patient and with pectoralis major musculocutaneous and deltopectoral flaps 154 days postoperatively in the other patient. Minor leakage occurred in these cases, and the initiation of oral intake occurred on postoperative days 108 and 197, respectively. These two patients could eat only gruel.

Group II

In group II (Table 3), in five patients whose defects were over half of the tongue or involved a mandibular bone, a free flap or pedicled musculocutaneous flap was used in the salvage reconstruction. Of these, one patient underwent a total glossectomy with laryngectomy for recurrent lingual cancer and immediate reconstruction with a rectus abdominis musculocutaneous free flap. Arterial thrombosis developed 3 hours postoperatively. Although thrombectomy and arterial anastomosis were achieved twice thereafter, the flap became unsalvageable. As thick scarring involved recipient vessels, we gave up on retransferring the free flap and chose reconstruction with a pedicled latissimus dorsi musculocutaneous flap. Leakage occurred postoperatively and took approximately 5 weeks to close with conservative treatment. The

Table 2. Patient Summary for Group I

Case	Age (yr)	Sex	History	Artery	Vein	Onset (POD)	Treatment at Thrombosis	Course	Initiation of Diet (POD)	Result	Follow-Up (POM)
1	62	M	NP	TCA	IJV†	3	Free jejunum (TCA, IJV)	No complication	11	Early initiation of oral intake, normal diet	15, death
2	68	M	Diabetes mellitus, arteriosclerosis obliterans, Y-graft for abdominal aortic aneurysm	STA*†	IJV†	3	Free jejunum (TCA, EJV)	No leakage, cerebral infarction (POD 6)	50	Soft diet	7, death
3	80	M	Diabetes mellitus, arteriosclerosis obliterans, myocardial infarction	STA†	IJV	8	DP, pharyngostomy, esophagostomy	PMMC, DP (POD 154), minor leakage	197	Gruel	8
4	74	F	Hypertension, cerebral infarction	STA†	IJV	2	DP, pharyngostomy, esophagostomy	PMMC (POD 68), minor leakage	108	Gruel	16

TCA, transverse cervical artery; STA, superior thyroid artery; IJV, internal jugular vein; EJV, external jugular vein; PMMC, pectoralis major musculocutaneous; DP, deltopectoral; POD, postoperative day; POM, postoperative month; NP, nothing particular; M, male; F, female.
*Both the artery and vein were thrombosed.
†Thrombosed vessel.

Table 3. Patient Summary for Group II

Case	Age (yr)	Sex	Disease (Preoperative RT)	Operation	Flap	Artery	Vein	Onset (POD)	Treatment at Thrombosis	Course	Initiation of Diet (POD)	Result	Follow-Up (POM)
5	74	M	Lingual cancer, PMMC reconstruction, recurrence (70 Gy)	Total glossolaryngectomy	RAMC	TCA*	IJV	0	Pedicled LDMC	Minor leakage, healed conservatively (RT = 50 Gy)	45	Gruel, died as a result of cancer recurrence	11, death
6	52	F	Lingual cancer recurrence (30 Gy)	Subtotal glossectomy	RAMC	TCA*	IJV	1	RAMC	Subcutaneous infection, healed conservatively (RT = 50 Gy)	54	Misswallowing, gruel, died as a result of cancer recurrence	5, death
7	72	M	Lingual cancer	Subtotal glossectomy	RAMC	FA*	IJV	1	RAMC (necrosis again, arterial thrombosis)	PMMC and DP (POD 7), minor leakage	40	Almost normal diet	6
8	48	M	Lingual cancer	Hemiglossectomy	ALT	FA*	IJV	1	Forearm	No complication	15	Normal diet, acceptable speech	66
9	60	M	Buccal mucosal cancer	Marginal mandibulectomy	Forearm	STA	IJV*	4	ATL	No complication	35	Normal diet, acceptable speech	30
10	51	M	Oral floor cancer	Local resection (4 × 8 cm)	Upper arm	STA*	IJV	1	Debridement only	No complication	14	Normal diet, acceptable speech	36
11	65	M	Oral floor cancer	Local resection (4 × 8 cm)	ALT	STA*	IJV	2	Debridement only	No complication	20	Normal diet, slight speech intelligibility	27

TCA, transverse cervical artery; STA, superior thyroid artery; FA, facial artery; LA, lingual artery; IJV, internal jugular vein; PMMC, pectoralis major musculocutaneous; RAMC, rectus abdominis musculocutaneous; ALT, anterolateral thigh; LDMC, latissimus dorsi musculocutaneous; DP, deltopectoral; POD, postoperative day; POM, postoperative month; RT, radiation therapy; M, male; F, female.
*Thrombosed vessel.

Table 4. Patient Summary of Group III

Case	Age (yr)	Sex	History	Disease	Flap	Artery	Vein	Onset (POD)	Treatment at Thrombosis	Course	Result	Follow-Up (POM)
12	56	M	Atrial fibrillation	Intraoral contracture, post–gingival cancer	Forearm	TCA*	EJV	0	Skin graft	Partial skin graft	Contracture, somehow released, recontracture	15
13	30	M	NP	Facial palsy and fistula, post–osteosarcoma of the mandible	LDMC	STA	FV*	6	Debridement only	Local flap, skin graft	Fistula closed, facial palsy no change	8

TCA, transverse cervical artery; STA, superior thyroid artery; EJV, external jugular vein; FV, facial vein; LDMC, latissimus dorsi musculocutaneous; POD, postoperative day; POM, postoperative month; NP, nothing particular; M, male; F, female.
*Thrombosed vessel.

patient began to eat perorally on postoperative day 45 day and had gruel.

In two patients who underwent subtotal glossectomy for lingual cancer and reconstruction with a rectus abdominis musculocutaneous flap, the contralateral rectus abdominis musculocutaneous flap was used for salvage reconstruction. In one patient, the reconstruction itself was successfully achieved with voluminous oral floor and root of the tongue, but the initiation of the peroral diet was postoperative day 54 because ingestion was difficult as a result of misswallowing. In the other patient, the flap degraded into total necrosis again because of arterial thrombosis. Reconstruction with a pedicled pectoralis major musculocutaneous and deltopectoral flap was performed. A peroral diet was initiated on postoperative day 40 and the patient could eat normal food.

One patient who underwent reconstruction with an anterolateral thigh flap following hemiglossectomy received a radial forearm flap transfer at salvage reconstruction. One patient who underwent reconstruction with a radial forearm flap following marginal mandibulectomy had anterolateral thigh flap transfer at salvage. In these two patients, no leakage occurred postoperatively, and both had acceptable speech and ate a normal diet.

In two patients with comparatively small defects (4 × 8 cm) of the oral floor, only debridement of the necrotic flap (anterolateral thigh, upper arm flap) and direct closure were selected. No leakage occurred postoperatively. These two patients could eat normally, although the restricted mobility of the tongue caused some speech ambiguity in one patient.

Group III

In group III (Table 4), one patient underwent free forearm flap transfer following release of the intraoral contracture. Arterial thrombosis occurred 8 hours postoperatively. Revascularization was achieved after reexploration. Thrombosis redeveloped after several hours and revascularization could not be achieved. We considered that the repeated arterial thrombosis might be associated with refractory atrial fibrillation with arrhythmia. We gave up on another free flap transfer and peeled the skin from the unsalvaged flap to use as a skin graft. The intraoral contracture was released incompletely.

One patient underwent functional reconstruction for facial palsy and orocutaneous fistula with a free latissimus dorsi musculocutaneous flap. On the first postoperative day, venous and arterial thrombosis developed. Revascularization using in-

Table 5. Patient Summary of Group IV

Case	Age (yr)	Sex	Disease (preoperative RT)	Flap	Artery	Vein	Onset (POD)	Treatment at Thrombosis	Course	Result	Follow-Up (POM)
14	42	M	Maxillary cancer maxillectomy, RAMC flap (FA, FV), parascapular OsC flap (LA, FV) (70 Gy)	Forearm with radius	STA (artery graft)	CFV* (venous graft)	5	Debridement of soft tissue, preserving bone	Removal of sequestrum, extracorporal RAMC flap with costal cartilage graft (POD 350)	No fistula formation, acceptable appearance, smooth oral intake	38
15	58	F	Maxillary cancer maxillectomy (70 Gy)	Scapular osteoadiposal	FA*	FV (venous graft)	Untraced	Debridement of soft tissue, preserving bone	Removal of sequestrum, RAMC flap with costal cartilage graft (POD 62)	No fistula formation, acceptable appearance, smooth oral intake	28
16	51	M	Maxillary cancer maxillectomy (40 Gy)	Forearm and scapular osteocutaneous	STA*	CFV	5	Debridement of soft tissue and bone	Observation	No change	3
17	50	M	Maxillary cancer maxillectomy (64 Gy)	Forearm and scapular osteocutaneous	STA*	EJV	4	Debridement of scapular flap, preserving FA flap and bone	Removal of sequestrum (POD 321)	No change	15
18	56	M	Mandibular defect, plate exposure (70 Gy)	Iliac bone	STA*	IJV	5	Debridement of soft tissue, preserving bone	Removal of sequestrum, fibular osteocutaneous with forearm flap (POD 150), venous thrombosis (POD 158), salvaged	No fistula formation, acceptable appearance, smooth oral intake, denture installed	25
19	57	F	Radionecrosis of the mandible (70 Gy)	Fibular osteocutaneous	TCA	IJV*	1	Debridement of soft tissue, preserving bone, DP flap	Removal of sequestrum (POD 76)	No change	20

TCA, transverse cervical artery; STA, superior thyroid artery; FA, facial artery; LA, lingual artery; IJV, internal jugular vein; EJV, external jugular vein; FV, facial vein; CFV, common facial vein; RAMC, rectus abdominis musculocutaneous; POD, postoperative day; POM, postoperative month; RT, radiation therapy; OsC, osteocutaneous; M, male; F, female.
*Thrombosed vessel.

terposed arterial and venous grafts was achieved. The next day, arterial thrombosis occurred but revascularization was achieved again. On postoperative day 6, however, venous thrombosis occurred. Revascularization could not be achieved despite an emergent operation. Debridement of the necrotic tissue was selected because the patient did not want further surgery at that time. Local flap transfer with a skin graft closed an orocutaneous fistula, but facial palsy remained unchanged.

Group IV

In group IV (Table 5), all six patients had a history of preoperative irradiation (40 to 70 Gy) and underwent reconstruction with free vascularized bone or osteocutaneous flaps. When the transferred free flaps were judged unsalvageable, five patients were treated conservatively with only debridement, whereas one patient (patient 19) underwent bone coverage with a deltopectoral flap in addition to removal of necrotic soft tissue. All transferred tissue was removed in one (patient 16) of six patients, whereas only soft tissue was removed while preserving bone in five patients. In all of the latter five patients, however, the bone degraded into sequestrum and was subsequently removed. Further reconstructions were performed in three patients but not in another three patients because they did not want further surgery. Salvage reconstructions performed in the former three patients were as follows. One patient underwent transfer of an extracorporeal rectus abdominis musculocutaneous flap with costal cartilage graft after a year. Further surgery with a tensor fascia lata graft was also performed. One patient underwent the transfer of a rectus abdominis musculocutaneous flap with costal cartilage approximately 2 months postoperatively that survived completely. These two patients obtained acceptable appearance and regular oral intake without fistula formation. One patient (patient 18) underwent reconstruction with conjoined fibular osteocutaneous and forearm flaps on postoperative day 150. The flaps developed venous thrombosis 7 days postoperatively but were salvaged with thrombectomy and venous reanastomosis, and survived completely. In this patient, dentures were installed successfully afterward and an acceptable appearance with regular oral intake was achieved.

DISCUSSION

Group I

In patients with advanced hypopharyngeal cancer who have undergone a pharyngoesophagectomy, the 2- and 5-year disease-specific survival rates are not high (72 and 52 percent, respectively).[9] Postoperative irradiation therapy is occasionally added.[10,11] Thus, in this group, early wound healing and early initiation of oral intake are in the patient's best interest. Free jejunal transfer is the most standard and reliable procedure of pharyngoesophageal reconstruction because of low complication rates and lower donor-site morbidity.[8,12] In free jejunal transfers, however, once vascular thrombosis occurs postoperatively, salvage with thrombectomy and reanastomosis is difficult because more than 3 hours' ischemia causes irreversible damage to the jejunum.[13,14] Because the jejunal graft with thrombosis quickly degrades into necrosis and infection spreads in the hypopharyngeal space, a salvage operation with removal of the necrotic graft should be performed as soon as possible. We believe that the best management for failed free jejunal transfer is another free jejunal transfer, as the harvest of a new jejunal segment is easy. Reconstruction using the intestines has significant advantages over cutaneous or musculocutaneous flaps,[15] and this is also true in salvage reconstruction after initial graft loss.[16] When a general or regional condition does not permit celiotomy, the radial forearm flap is a conceivable option because it is less invasive and allows early mobilization.[8,17] Salvage reconstruction using a pedicled flap (e.g., pectoralis major musculocutaneous flap) should be used only in cases where recipient vessels are unavailable. In our two cases where free jejunal transfer was performed secondarily, we experienced little difficulty in harvesting the jejunum again. Boyd et al.[18] reported after an anatomical study of three fresh cadavers that any part of the jejunum or ileum is suitable for transfer in terms of the ratio of chord to arc length. Conservative treatment with pharyngostoma and esophagostoma formation requires several further operations and a long time to the initiation of oral intake. Patients 3 and 4 are our early cases.

Group II

In this group, early initiation of oral intake, final swallow function, and speech were measured to assess the subsequent treatments. When a free flap transferred at the initial intraoral reconstruction fails, the optimal treatment should be determined depending on the size and location of the defects. When a defect is not less than half of the tongue, salvage reconstruction with either a cutaneous or musculocutaneous flap (pedicled or

free) should be performed as permitted by the patient's general condition. If conservative treatment with the debridement of necrotic tissue and formation of pharyngostomy are carried out, several further operations are required before the initiation of oral intake. Such conservative treatments often make the general condition worse because of lasting inflammation in the pharyngeal space, and exposure of the large vessels might result in their rupture.

When the defects are extensive (e.g., subtotal or total glossectomy, total glossectomy with laryngectomy), we believe that salvage reconstruction with a voluminous free musculocutaneous flap is the first choice, such as a (contralateral) rectus abdominis musculocutaneous flap. In our two cases that received a salvage free rectus abdominis musculocutaneous flap transfer because of a failed free rectus abdominis musculocutaneous flap transfer, we experienced little difficulty in reharvesting the rectus abdominis musculocutaneous flap. A weakened abdominal wall is a probable complication, for which reinforcement of the abdominal wall with a tensor fascia lata flap or artificial mesh is mandatory to prevent hernia. A free latissimus dorsi musculocutaneous flap is a possible alternative for such a large defect. In one series, one patient underwent pedicled latissimus dorsi musculocutaneous flap transfer as salvage reconstruction because the scar spread over the operating field and no appropriate recipient artery was available near the defect. End-to-side anastomosis to the external carotid artery or the use of the thoracoacromial artery as a recipient was a probable option, but we considered that the patient's general condition would not permit further surgery if thrombosis reoccurred.

When the defects are intermediate (e.g., hemiglossectomy), the use of a radial forearm flap is preferred to an anterolateral thigh perforator flap because the radial forearm flap is technically easier to transfer and has lower failure rates than the anterolateral thigh flap.[19] Surgeons should consider the flap success rate as the most important factor in choosing the flap, especially after loss of the initial flap. In one patient, however, an anterolateral thigh flap was used in the salvage reconstruction because the left forearm flap had already been used and nutrient vessels of the right forearm were damaged by arterial and venous lines. Our two patients in this category experienced no complications after salvage operation and could eat normally and had acceptable speech. A pectoralis major musculocutaneous flap is a conceivable alternative for such defects. When the defects are restricted for the most part to the oral floor, direct closure of the defect is possible,[20] although salvage reconstruction with a free flap or pedicled flap is better from a functional viewpoint.[21] In two patients with a defect of the oral floor, direct closure of the defect was chosen at the time of flap loss. These two patients commenced oral intake by postoperative week 3 and ultimately ate normal food, although the speech of one patient could not be well understood.

Group III

Reconstructions performed in group III were secondary and were designed chiefly for the purpose of functional improvement. In such cases, flap loss means little change in the recipient between the preoperative and postoperative states, whereas another free flap transfer requires another donor-site sacrifice. Thus, in this group, consideration of the patient's opinion and the estimated rate of success determine whether salvage reconstruction should be performed in the acute setting soon after thrombosis. When the release of contracture is the chief objective of surgery, a skin graft using a portion of skin taken from the lost flap can provide some improvement. Because our patient 11 had refractory arterial fibrillation, which we consider a serious cause of arterial thrombosis, we rejected the retransfer of the free flap. When a free flap transfer failed because of arterial thrombosis in patients with refractory atrial fibrillation, the indication of another free flap transfer should be determined after due consideration because the previous arterial thrombosis might be associated with atrial fibrillation.

Group IV

Group IV comprised the most challenging cases because the reconstructions were secondary, preoperative irradiation had been performed, and bony reconstruction was required in all cases. In this group, the success rate of flap survival, control of infection, and the aesthetic appearance and smoothness of oral intake should be included to evaluate the salvage treatment. Nakatsuka et al.[3] reported that the flap survival rate in secondary reconstruction was significantly lower than in immediate reconstruction because the available recipient vessels are limited and the risk of infection and delayed wound healing is predominantly attributable to scar formation and persistent inflammation caused by digestive juices. Furthermore, osteocutaneous flaps were almost five times more likely to fail than soft-tissue flaps.[2] In our series,

when the transferred osteocutaneous or osteoadiposal flap was judged unsalvageable, only the soft tissue was removed, preserving bone in five of six cases. However, postoperative follow-up revealed that the grafted bone degraded into the sequestrum and was subsequently debrided in all five cases. In regions other than the head and neck, a free (nonvascularized) bone graft is one option for bony reconstruction. However, in the nasopharyngeal space, nonvascularized bone can sustain infection and degrade into the sequestrum, especially in secondary cases. Successful reconstruction of maxillary defects with a free vascularized bone (osteocutaneous) flap has been reported, including fibular,[22] scapular,[23] radial,[24] and iliac[25] bone or osteocutaneous flap. In general, however, osteocutaneous flaps (fibular, scapular, iliac) do not have a vascular stalk as long as that of the rectus abdominis musculocutaneous or the latissimus dorsi musculocutaneous flap. In our initial free flap transfer for maxillary reconstruction, venous and/or arterial interposition was used in two cases to obtain a long vascular pedicle, and a scapular osteocutaneous flap was used with a forearm flap in two cases. Flaps requiring a vein graft have a higher rate of flap loss than those that do not.[2] It may not be in the patient's best interest for a bone flap transfer such as a fibular flap to be repeated in the acute setting at the time of flap loss. When a secondary bony reconstruction fails because of vascular thrombosis, we consider that free rectus abdominis musculocutaneous or latissimus dorsi musculocutaneous flap transfer combined with costal cartilage or rib[26,27] is the recommended option because latissimus dorsi musculocutaneous and rectus abdominis musculocutaneous flaps have long pedicles with large-caliber vessels that are technically easier to work with. These flaps can also be used in an extracorporeal manner. Extracorporeal transfer requires only minimal dissection in the recipient, which can avoid exposure of the great vessels and spread of infection. The use of a titanium mesh in combination with a rectus abdominis musculocutaneous flap[28] or simple maxillary reconstruction using a rectus abdominis musculocutaneous flap and prostheses[29] is an option to be considered. Salvage reconstruction using a common osteocutaneous flap with another flap or with a vein and/or arterial graft would result in a high rate of vascular thrombosis.

Once the free flap used in the immediate reconstruction is judged unsalvageable, salvage reconstruction should be performed as promptly as possible. Treatment delay causes the spread of infection and may result in exposure of the great vessels, leading to rupture. Salvage treatment should be determined following the patients' wishes, considering many factors including regional and general conditions and existing complications, of which the success rate should be considered by surgeons as the most important factor. Even in salvage reconstruction after free flap loss, we believe that retransfer of the free flap is the best choice for large soft-tissue defects to the extent that general and regional conditions permit. In our series, the success rate of the repeated free flap was 89 percent (eight of nine patients): five of six patients (83 percent) who underwent soft-tissue reconstruction in the acute setting and three of three patients (100 percent) who underwent soft- and hard-tissue reconstruction in the late setting. Compared with the pedicled flap, free flap transfers have the advantage of a large degree of freedom for transfer and good blood supply throughout the flap. In free flap transfer in the head and neck, partial necrosis of the flap is rare,[2,3] whereas the pedicle flap tends to sustain partial necrosis of the distal parts, especially in cases where a large flap is required. When regional and general conditions do not permit further free flap transfer or when defects are comparatively small, re-reconstruction with a pedicled flap should be considered. We occasionally have difficulty in selecting suitable recipient vessels for the retransfer of free flaps. When branches of the external carotid or subclavian artery are not available for the recipient, we prefer to apply end-to-side anastomosis directly to the external carotid artery.[30] The thoracoacromial artery is also usable. Regarding the recipient vein, at least one of the internal or external jugular veins is usable in most cases. When none is available, a turned-over cephalic vein or thoracoacromial system might be usable.[14]

CONCLUSIONS

When a free flap is judged unsalvageable, treatment should be determined on the basis of many factors, of which the success rate should be considered by surgeons as one of the most important. We believe that retransfer of the common free flap is the best choice for large soft-tissue defects at thrombosis. When the regional or general conditions do not permit further free flap transfer or when defects are comparatively small, re-reconstruction with a pedicled flap should be considered. For soft- and hard-tissue defects, simple reconstruction with a common free flap with a long vascular stalk such as the rectus abdominis musculocutaneous or latissimus dorsi musculocu-

taneous flap combined with costal cartilage or rib is the recommended option.

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JOHNS
特集■医療におけるトラブルをめぐって－予期せぬ出来事への対応

頭頸部癌領域

移植組織の壊死

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Takashi NAKATSUKA

● Key Words ●トラブル，遊離組織移植，血栓，壊死●

はじめに

頭頸部領域の腫瘍切除後の組織欠損の再建には，古くより形成外科的手技が多用されてきた。再建方法としては，比較的小範囲の欠損であれば，植皮術や局所皮弁移動術が用いられ，欠損範囲が大きくなると有茎(筋)皮弁移植術や遊離(筋)皮弁移植術が適応となる。

これらは基本的に健常組織の移動・移植による欠損・変形部位の再建という形をとるため，単なる病変部の切除・縫合という基本的外科手技とはいくつかの点で異なる。具体的には，組織採取部は本来病変とは関係のない健常部であり，そこに新たな瘢痕・変形を生じうること，また，組織移動の方法にはいくつかあるが，広範囲組織欠損に対する大きな組織の移動になればなるほど，合併症の発生率が高くなり，また移植する組織の血流循環不全による組織壊死が起こりうることである。

特に，頭頸部領域の癌切除後の広範囲組織欠損の再建例において，移植組織に壊死が生じると，致命的な合併症につながる危険性があり，早急な対応が必要となる。そこで本稿では，有茎(筋)皮弁や遊離(筋)皮弁移植における皮弁壊死の問題，特に後者に関する問題点を中心に述べる。

Ⅰ．移植組織の壊死

有茎(筋)皮弁は，移植組織の栄養血管の連続性を温存したまま，その血流支配領域の組織を欠損部に移植する方法であるが，問題点として血流のもっとも少ない部分が欠損部に充填されるという欠点を有する。そのため，広範囲組織欠損などで皮弁に緊張がかかる場合などには部分壊死が生じやすくなる。また，放射線照射症例など移植床の血行状態が不良な場合には合併症の頻度が高くなりやすい。

そこで最近では，血流がより豊富で移植組織の自由度が高く，必要な組織を必要な量だけ移植できる遊離組織移植術が，有茎(筋)皮弁よりも術後合併症が少ないとの経験に基づき，多くの施設で第一選択として用いられている。そしてその結果，機能的にも形態的にも良好な術後成績が得られるようになっている[1,2]。

しかし，遊離組織移植術の場合には，手術用顕微鏡下の血管吻合という特殊技術を要し，欠損部の近傍に健常な一対の動静脈が存在することが必要不可欠である。さらに，口径が1～3 mmの血管同士の吻合を行うため，血管の捻れ，圧迫，血管壁の変性，炎症の波及などによる吻合部血栓で容易に血管閉塞を生じ，皮弁壊死に陥ることがある。

頭頸部癌切除後の再建におけるこれまでの多数症例の解析では，皮弁壊死率は2～7%と報告されている[2～5]。

なお，微小血管において吻合部閉塞をきたしやすい因子としては，高齢，喫煙，肥満，高血圧，糖尿病，術前放射線照射などが考えられる。しかし，諸家の報告によると，頭頸部再建においてはそれらの因子が皮弁壊死の直接原因とは必ずしも認められていない[4,6]。われわれの経験でも，高齢者であるだけで術後血管閉塞が起こりやすいとの明らかな結果は得られていない。ただ，一般論

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として高齢者ほど，また，多量の放射線照射が照射されているほど術後合併症を生じやすい傾向にはある[5]。

上記のような術後早期の血管閉塞以外に，遅発性の血管閉塞も遊離組織移植の場合には問題となることがある。一般に遊離組織移植術を行った場合，移植された組織と移植床の組織との間には血管新生を伴う血行再開が確立され，移植組織の量・質および移植床の血行状態にもよるが，通常は2〜3カ月もすれば，その時点で万が一吻合血管に閉塞が生じても移植組織の全壊死は起こらないと考えられている。しかし，広背筋皮弁移植後7カ月で栄養血管結紮により皮弁壊死に陥ったとの報告もある[7]。また，まれではあるが，口腔内に移植した遊離皮弁が数カ月から数年の内に萎縮することを実際の臨床で経験したこともある。

この遅発性血管閉塞で特に問題となるのが，遊離空腸移植の場合である。空腸は外壁が漿膜のため，一般には移植床の組織から腸壁に侵入するような血管新生は起こりづらいと考えられている。したがって，その生着は半永久的に吻合血管からの血流に頼っていると考えられる。しかし，犬を用いた最近の実験では，臨床に近いモデルとして15 cmの遊離空腸を頸部に移植し，28日目に栄養血管を結紮しても空腸は100%生着し，周辺組織からの新生血管の侵入も認めたと報告されている[8]。

このように遊離移植組織の長期的な変化に関しては，種々の報告があり，その栄養血管の遅発性閉塞がどのような影響を皮弁に及ぼすかは，症例ごとに判断しなければならないと考えられる。

II. 移植組織壊死を生じた場合の問題点

頭頸部癌切除後の再建例で，移植組織に壊死をきたした場合，部分壊死であれば局所の洗浄などの保存的治療で治癒を期待することも可能である。しかし，移植組織の全壊死となった場合は，壊死組織の除去と同時に，欠損部を何らかの形でできるだけ早く被覆する救済手術が必要となる。その理由としては，頭頸部領域は唾液にさらされるため，頸部郭清により剝離・露出された内外頸動脈・頸静脈に炎症が及ぶと，致命的な大出血をきたすことがあるからである。そして，多くの場合壊死に陥った移植組織に代わる新たな組織の移植が必要となるが，救済手術の主眼はあくまで不良組織の除去と創被覆による炎症の沈静化になる。

上述したように，遊離組織移植での再建が現在は最も機能・形態とも良好な結果が得られるため，できる限り再手術も別の遊離組織移植を行うことが望ましいが，皮弁全壊死に陥った場合には，創部の感染や血栓形成などのため遊離組織の再移植が難しいことが多く，その場合には有茎(筋)皮弁を選択することとなる[9]。いずれにしても，救済手術後の形態や機能は初期に予想された手術結果に比べ劣ることになりやすい。

III. 組織壊死の予防

遊離組織壊死の予防には，欠損部に適した移植組織の選択と正確なデザイン，愛護的な挙上手技，健全な移植床血管の選別，的確な吻合手技，吻合血管の捻れや圧迫の防止，吻合血管周囲への術後感染の波及防止，などが挙げられる。

特に，遊離組織移植を用いた頭頸部癌切除後の再建では，吻合血管の閉塞の約80%は術後3日以内に生じている[3]。つまりその間は，移植組織自体の血流チェック(pin prick testによる出血の確認やcapillary refillingによる皮膚表面血流の消褪の有無）や超音波ドップラーによる吻合血管の血流音の確認を頻回に行っておくことが望ましいといえる。そして吻合血管の閉塞が疑われた場合には，直ちに再手術を行うことが肝要である。早期の発見であれば，血栓除去および血管再吻合で移植皮弁を十分に救済できるからである。

まとめ

頭頸部癌切除後の遊離組織移植術は，今や広範囲組織欠損例の第一選択とされ，良好な成績を収めているが，吻合血管の閉塞による移植組織壊死が3〜4%の頻度で生じることも事実である。術前には，本法の有用性に加え，これらの危険性を十分に患者さんとその家族に説明を行っておくことが必要であると考える。

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ORIGINAL ARTICLE

Reconstruction of maxillectomy defects with free flaps - comparison of immediate and delayed reconstruction: A retrospective analysis of 51 cases

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Abstract

To establish a standard reconstructive material we compared outcomes after immediate and delayed reconstruction. Of the 21 patients who had immediate reconstruction, six patients had upper horizontal plane reconstruction. All bone grafts survived without infection or absorption. Of the 30 patients who had delayed reconstruction, 22 patients had upper horizontal plane reconstruction, with vascularised bone in 14 patients, non-vascularised bone or cartilage in five patients, and hydroxyapatite bone block in three. Postoperative infections developed in three of four patients for whom costal cartilage was used, and in all three patients for whom hydroxyapatite blocks were used. Non-vascularised bone or cartilage grafts are preferable for immediate reconstruction because of their technical simplicity. Vascularised bone grafts or osteocutaneous flaps are preferable for delayed reconstruction, however, as in most cases the operating field is contaminated by bacterial.

Key Words: *Maxilla, reconstruction, microsurgery, free flap, free bone, vascularized bone*

Introduction

Restoration of composite tissue defects after maxillectomy remains a difficult problem, as various adjacent structures such as the paranasal sinuses, palate, nasal cavity, orbital contents, skull base, oral mucosa, and cheek skin are often excised together with the maxillary bone. The timing of reconstruction is also difficult, and remains controversial. Some oncologists recommend avoiding immediate reconstruction after ablative excision of maxillary cancer to facilitate inspection for recurrent tumour, although there are numerous ways to monitor this nowadays. Reconstruction has also been recommended, as this allows enough of the maxilla and surrounding affected tissues to be removed, so increasing the range of indications for maxillectomy as a curative treatment [1]. The timing and need for reconstruction remain contentious issues among oncologists, while there has been little discussion among reconstructive surgeons. Various opinions have been put forward about optimal reconstructive materials and procedures for the midface, and standard methods of reconstruction have not yet been established.

We present a retrospective analysis of 51 patients who had either immediate ($n=21$) or delayed ($n=30$) reconstruction after maxillectomy using free flaps.

Patients and methods

Patients

Between 1993 and 2004, a total of 51 patients (36 men, 15 women) had maxillary and midfacial reconstruction at the University of Tokyo Hospital (1993–2002) and Kyorin University Hospital (2003–2004). Patients who required maxillectomy mainly had maxillary cancer, with the exception of

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one with osteosarcoma of the maxilla and one patient with adenocarcinoma of the lacrimal gland. Mean age at operation was 56 years (range 20 to 74). Twenty-one had immediate (primary) reconstruction after resection, and 30 patients had delayed (secondary) reconstruction after a follow-up period.

Types of reconstruction

The flaps used are shown in Table I. Radial vessels or dorsalis pedis were grafted between pedicles of the transferred flaps and recipient vessels when recipient vessels were too far away from the pedicle vessels of the transferred flap.

Reconstruction of bony support

The midface and orbits are described as a structural unit [2,3]. We also simplified the maxilla as follows (Figure 1). The three vertical buttresses of the maxilla include the nasofrontal, zygomatic, and pterygomaxillary buttresses. The two horizontal planes include the lower horizontal plane, chiefly consisting of the palatal bone and maxillary alveolus, and the upper horizontal plane, comprising the orbital floor and zygomatic arch. In this series, vascularised bones, non-vascularised bones or cartilages, and hydroxyapatite blocks were used to reconstruct the upper horizontal plane.

Results

Failure of flaps

Following immediate reconstruction, arterial thrombosis was seen in one patient, and prompt exploration and reanastomosis resulted in successful salvage of the flap. Flap transfer was successful in all cases when used for immediate reconstruction. With delayed reconstruction, however, arteries thrombosed in three patients and veins in three patients.

Table I. Material used in immediate and delayed reconstruction.

Reconstructive material	Number of patients	
	Immediate ($n=21$)	Delayed ($n=30$)
Rectus abdominis musculocutaneous flap	16	12
Scapular osteocutaneous flap	2	10
Latissimus dorsi-serratus anterior muscle rib osteomyocutaneous flap	2	0
Latissimus dorsi musculocutaneous flap	1	0
Radial forearm osteocutaneous flap	0	3
Anterolateral thigh flap	0	3
Fibular osteocutaneous flap	0	1
Radial forearm flap	0	1

Although we tried to salvage three flaps by vascular reanastomosis, the flap necrosed completely. All three necrosed flaps required interpositional vessel grafts or a forearm flap as an interpositional flap, as the pedicles could not reach the recipient vessels. The success rate with delayed reconstruction was therefore 90%.

Reconstruction of the upper horizontal plane

Table II shows the results of reconstruction of the upper horizontal plane, comprising the orbital floor and zygomatic prominence. Of 21 patients who had immediate reconstruction, bones comprising the upper horizontal plane including the Lockwood ligament were excised in 18. Of these 18, six reconstructions used vascularised bone (scapula and rib, $n=2$ each) or non-vascularised costal cartilage ($n=2$). All bone grafts survived without infection or absorption.

Of 30 patients whose reconstruction was delayed, the upper horizontal plane including the Lockwood ligament was lost in 26 patients. Of these 26 patients, 22 reconstructions involved vascularised bone (scapula, $n=10$; radius, $n=3$; fibula, $n=1$), non-vascularised bone, or cartilage (costal cartilage, $n=4$; cranium, $n=1$) or hydroxyapatite block ($n=3$). Postoperative infection developed in three of four patients in whom costal cartilage was used, and in all three patients who had a hydroxyapatite block. Materials used for reconstruction were resected in all six patients with postoperative infection.

Reconstruction of the eye socket

The eye was excised or enucleated in 16 patients who had immediate reconstruction, and it had already been done in six patients who had delayed reconstruction. With immediate reconstruction, three patients underwent simultaneous reconstruction of the eye socket using a skin portion of the scapular osteocutaneous flap ($n=2$) or rectus abdominis musculocutaneous flap ($n=1$). The eye socket was not reconstructed in the other 13 patients. With delayed reconstruction, two of the six had their eye sockets reconstructed using rectus abdominis musculocutaneous flaps.

Reconstruction of the base of skull

The anterior base of the skull was resected in eight patients. All patients had immediate reconstruction using rectus abdominis musculocutaneous flaps to seal the brain from the nasoethmoidal space and prevent infection.

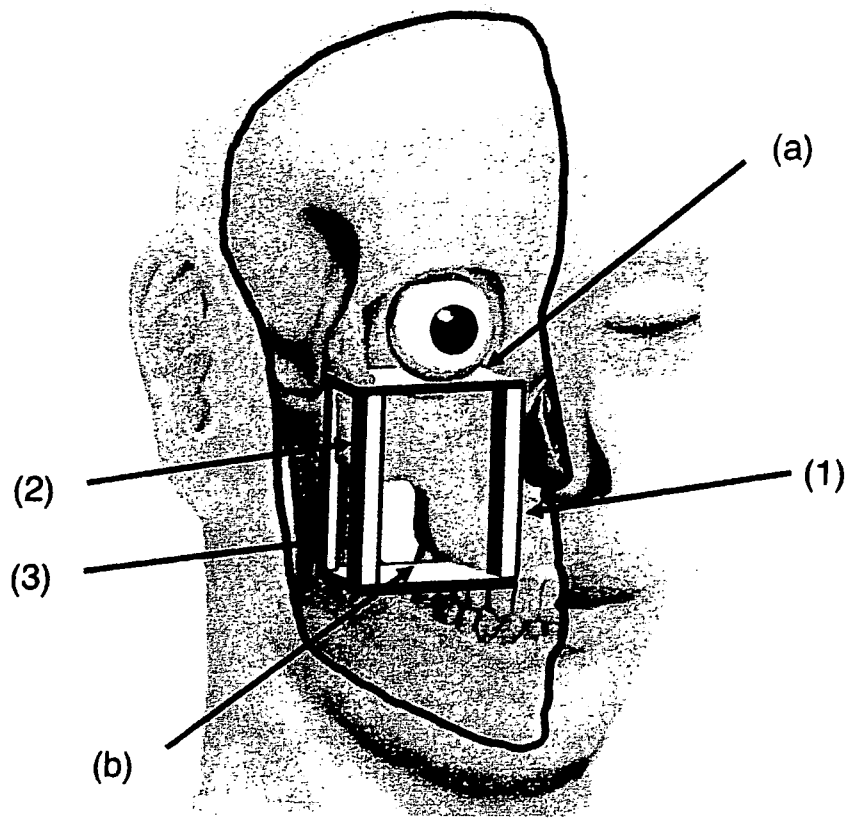

Figure 1. Diagram of the midface. The three vertical buttresses of the maxilla include the nasofrontal (1), zygomatic (2), and pterygomaxillary (3) buttresses. The two horizontal planes include the upper horizontal plane (a) consisting of the orbital floor and zygomatic arch, and the lower horizontal plane (b) chiefly consisting of the palatal bone and maxillary alveolus.

Case reports

Case 1

A 51-year-old man presented with squamous cell carcinoma of the left maxillary sinus. After 30 Gy of preoperative radiotherapy, and chemotherapy using 5-fluorouracil and cisdatin, the maxilla including the upper and lower horizontal planes was resected en bloc, preserving the orbital contents, together with a radical neck dissection. The upper horizontal plane was reconstructed using non-vascularised eighth and ninth costal cartilages, which were fabricated and fixed to the remaining frontozygomatic process and zygomatic arch with titanium miniplates. A rectus abdominis musculocutaneous flap with two cutaneous islands was used for reconstruction of the palate and nasal lining. His postoperative course was uneventful, with no infection or exposure of cartilages. Four years postoperatively, the position of his eyes is symmetrical, and he has no double vision, but the left cheek is slightly depressed (Figure 2).

Table II. Success rate of bone and cartilage grafts for reconstruction of the orbital floor. Data are number of patients.

Material used for reconstruction	Number of patients who survived	
	Immediate ($n=6$)	Delayed ($n=22$)
Vascularised bone	4	14
Non-vascularised bone and cartilage	2	5
Implant	0	3

Case 2

A 66-year-old woman presented with severe facial deformity and double vision caused by downward dislocation of the left eye after resection of squamous cell carcinoma of the left maxillary sinus. As the palate was not resected and the soft tissue defect was small, a 4×2 cm piece of calvarial bone was used to reconstruct the orbital floor and restore the position of the eye. An anterolateral thigh flap was used to cover the transferred calvarial bone and to reconstruct the facial skin defect created in the lower lid region by repositioning the slipped eyeball to avoid ectropion. One year postoperatively, her double vision has vanished, and her facial contours are improved (Figure 3). The anterior thigh skin gave a poor colour match to the cheek, and was later replaced with a skin graft from the preauricular skin.

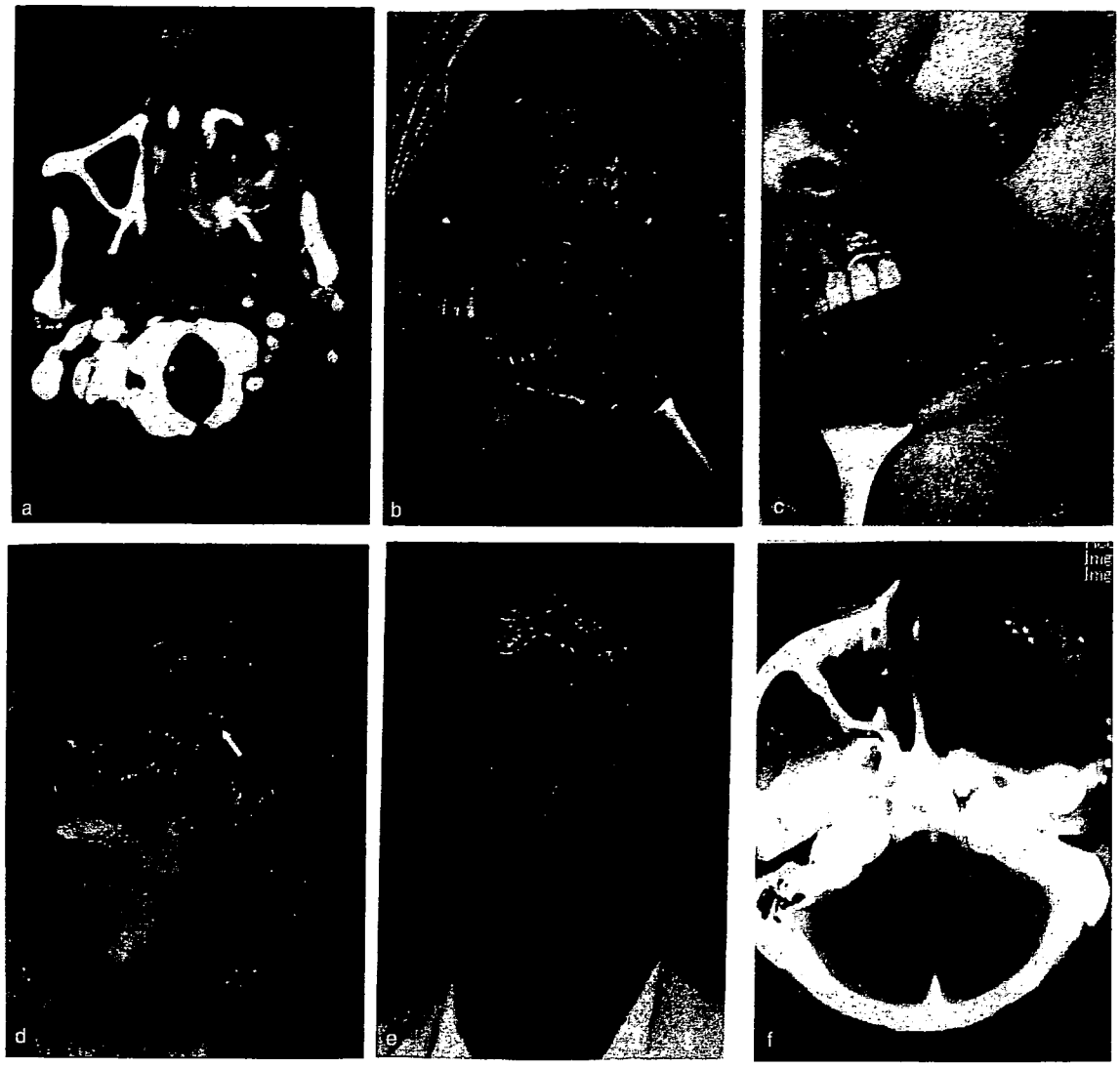

Figure 2. Case 1. (*a*) Preoperative computed tomogram. (*b*) Immediately after the en bloc excision using the Weber-Fergusson approach. (*c*) The rectus abdominis musculocutaneous flap was set in the defect to create the oral and nasal lining. (*d*) The non-vascularised rib cartilage (→) was fabricated and fixed to the remaining frontozygomatic process and zygomatic arch with titanium miniplates. (*e*) Postoperative appearance at four years. (Published with the patient's consent). (*f*) Postoperative computed tomogram at four years.

Case 3

A 27-year-old man had a spindle cell sarcoma of the left maxilla resected. After a period of three years he complained of double vision and oronasal incompetence as a result of the resection of the palate. Because the defective maxilla with its bacterial contamination had to be removed for palatal closure, vascularised scapula was used for the reconstruction of the upper horizontal plane and a scapular flap was used for obliteration of the maxilla. Three years postoperatively the patient can speak well and eat without dentures, although the alar base is slightly depressed (Figure 4).

Discussion

The midface contains highly specialised structures that serve multiple functions confined within a small space, and is therefore exceedingly complicated. Reconstruction of defects is a challenge to reconstructive surgeons. Microvascular tissue transfer has dramatically changed the way we reconstruct the head and neck, and also forms the mainstay for reconstruction after maxillectomy. However, there are various opinions about which materials and methods are best for the midface. Some reconstructive surgeons have recently advocated that midfacial skeletal reconstruction after resection should be

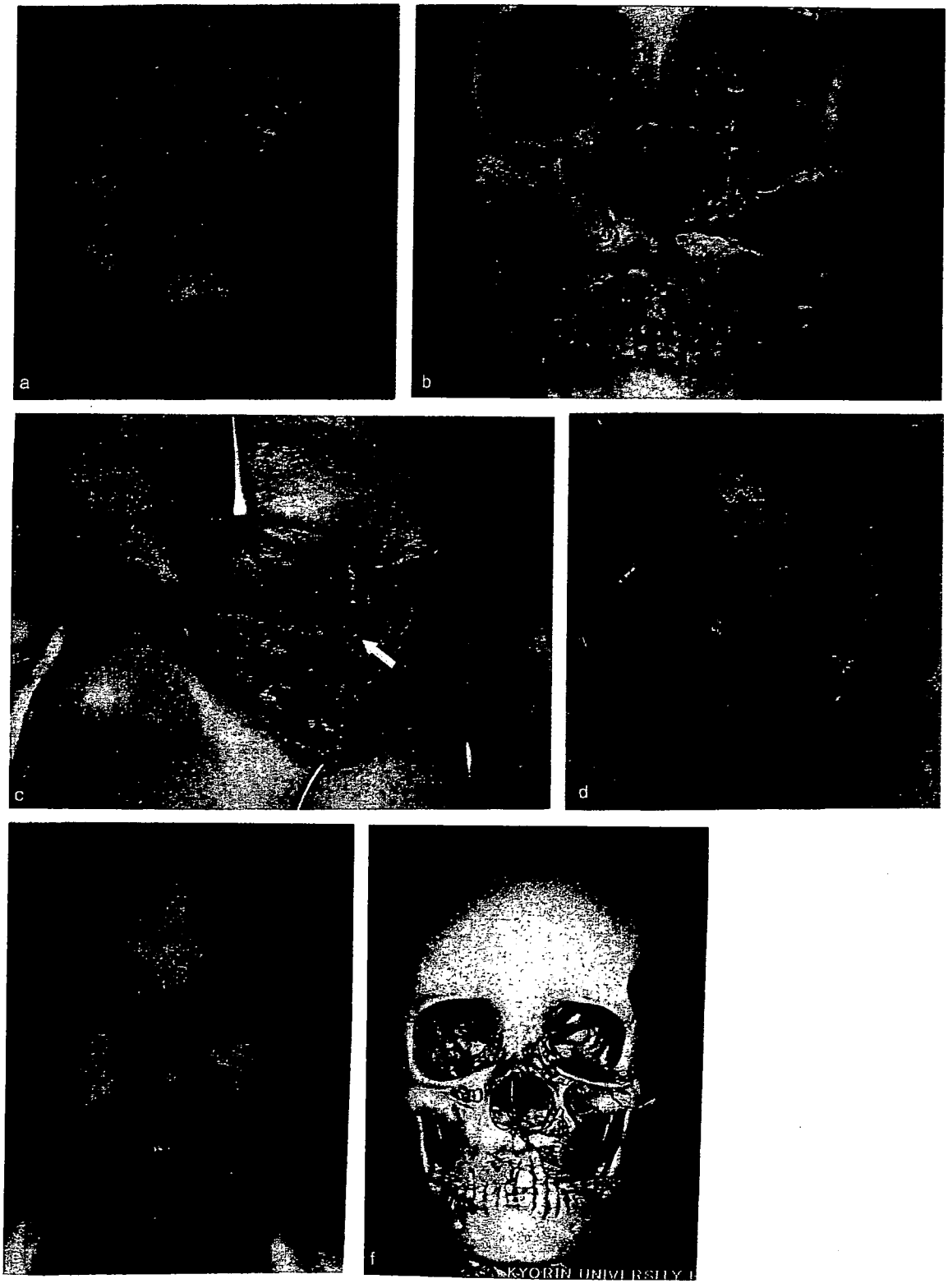

Figure 3. Case 2. (*a*) Preoperative appearance. (Published with the patient's consent). (*b*) Preoperative three-dimensional computed tomogram. (*c*) Calvarial bone (→) was used to restore the position of the eyeball. (*d*) An anterolateral thigh flap was used to cover the transferred calvarial bone and to reconstruct the facial skin defect. (*e*) Postoperative appearance at one year. (Published with the patient's consent). (*f*) Postoperative three-dimensional computed tomogram at one year.

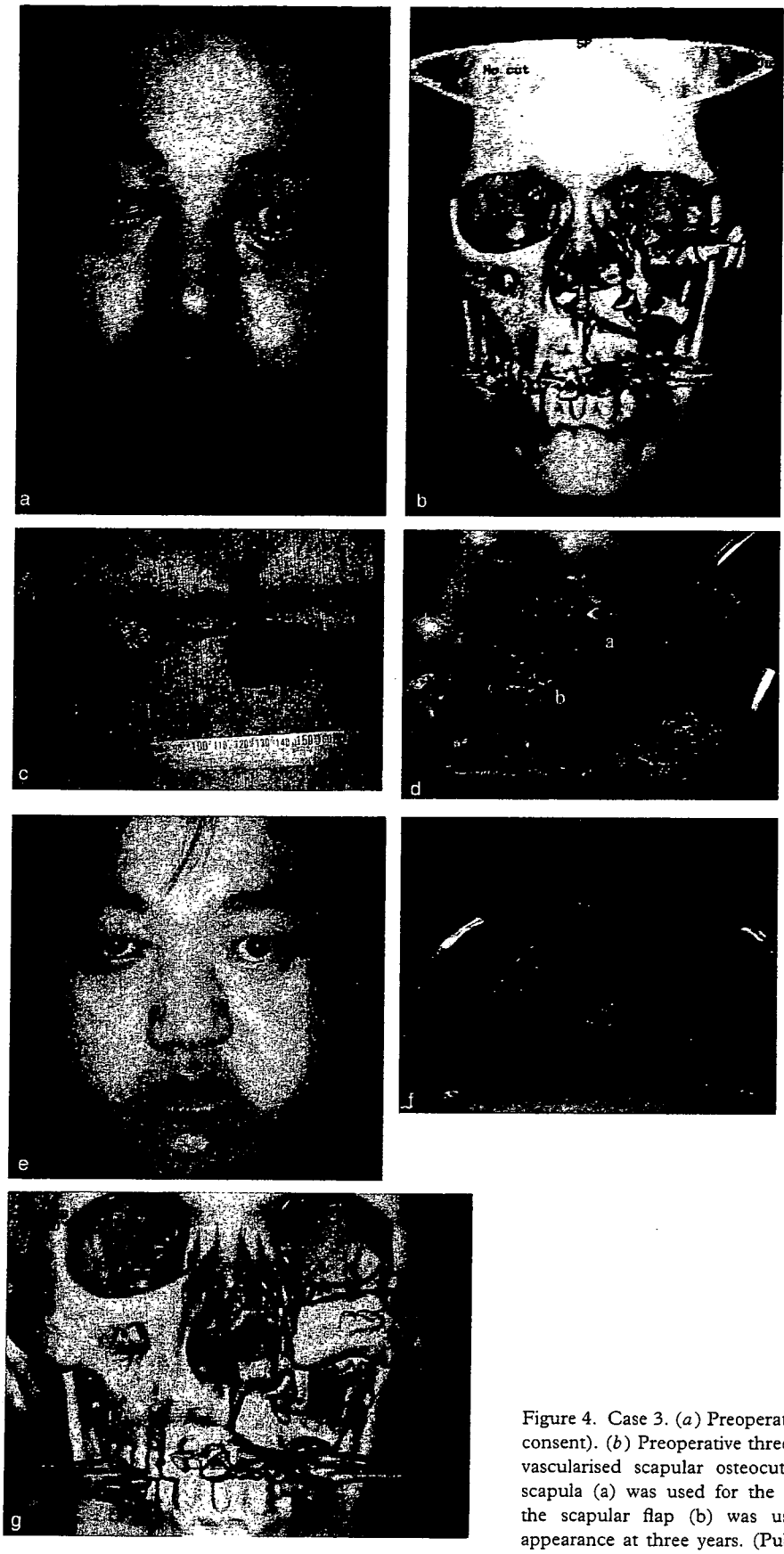

Figure 4. Case 3. (*a*) Preoperative appearance. (Published with the patient's consent). (*b*) Preoperative three-dimensional computed tomogram. (*c*) The vascularised scapular osteocutaneous flap that was harvested. (*d*) The scapula (a) was used for the upper horizontal plane reconstruction, and the scapular flap (b) was used for palatal closure. (*e*) Postoperative appearance at three years. (Published with the patient's consent). (*f*) The palate closed by the scapula flap. (*g*) Postoperative three-dimensional computed tomogram at three years.

based on the principles of the restoration of maxillary buttresses [3,4]. The concept of maxillary buttresses was originally described by Sicher and DeBrul [5] and re-emphasised by Manson et al. [6] and Gruss and Mackinnon [7] in the treatment of Le Fort-type facial fractures. The three maxillary buttresses are the medial buttress (nasomaxillary buttress), the lateral buttress (zygomaticomaxillary buttress) and the posterior buttress (pterygomaxillary buttress). According to Gruss and Mackinnon [7], reconstruction of the anterior (medial and lateral) buttresses is important for exact vertical height and horizontal projection of the maxilla. These concepts attach great importance to vertical skeletal supports and simplify the treatment of complicated facial bone fractures. These concepts are absolutely true in the treatment of the Le Fort-type fracture in which the midface is often shortened vertically.

In reconstruction of the maxilla after tumour ablation, however, vertical reconstruction is rarely required because posterior components of the midface such as posterior wall of the maxillary sinus and pterygomaxillary buttress almost always remain. Vertical height of the maxilla is rarely shortened after maxillectomy, even in total maxillectomy. Conversely, horizontal planes such as the orbital floor (upper horizontal plane) and palate (lower horizontal plane) are often resected. Coleman therefore proposed an alternative concept for maxillary reconstruction after tumour ablation, in which midfacial bones are simplified into a truncated pyramidal shape and functional surfaces of the midface buttress include the infraorbital area, palate, lateral nasal wall, and buccal-malar skin [2]. Coleman noted that reconstruction of the entire structure is usually impractical and satisfactory reconstruction can be performed by obliterating the central cavity and replacing the important surfaces (orbital, palatal, and malar) using vascularised bone and soft tissue flaps.

Our concept of the maxillary structure is shown in Figure 1. The three vertical buttresses of the maxilla including the nasofrontal, zygomatic, and pterygomaxillary buttresses, maintain midfacial projection and vertical height. The concept of buttresses means vertical supports, so buttresses primarily comprising orbital and palatal bones should be named horizontal planes rather than buttresses, to avoid confusion in terminology. Of the two horizontal planes, the lower horizontal plane consists mainly of palatal bone and maxillary alveolus, and provides a normal occlusal plane for the mandible. This also maintains facial width and proportion in close connection with the vertical buttresses. The upper horizontal plane, consisting of the orbital floor and zygomatic arch, supports the eyes and forms the zygomatic prominence, which is also aesthetically important in manifesting three-dimensional form of the face.

Maxillary reconstruction should be planned according to these anatomical characteristics. We think that reconstruction of all three vertical buttresses is unnecessary, because the posterior wall of the maxilla is almost always left intact after resection, which is a distinct difference from a Le Fort-type fracture. As a result, the vertical height of the maxilla can be retained without reconstruction. Bony reconstruction of the nasofrontal vertical buttress is clearly important to avoid depression of the alar base. The pterygomaxillary buttress and lower horizontal plane are likewise important for osseointegration. However, reconstruction of this buttress and plane using a vascularised bone transfer is difficult, and these problems can be resolved simply using maxillary prostheses [8]. A depressed alar base can be raised by dentures, with only reconstruction of the medial nasal wall with a soft tissue flap. Osseointegration is hardly required for patients with maxillary cancer, who typically have a poor prognosis. The zygomatic buttress, while certainly important for malar prominence, can be achieved by reconstruction of the upper horizontal plane. On the other hand, reconstruction of the upper and lower horizontal planes is more important than that of the vertical buttresses. Restoration of downward deviation of the orbit because of loss of the upper horizontal plane is critical for the treatment of double vision and facial aesthetics. Although many surgeons admit that the upper horizontal plane (orbital floor) should be reconstructed using hard tissue, some have suggested that vascularised bone should be used to avoid infection or absorption of transferred bone [4,9,10], while others have reported the safety of a non-vascularised bone graft [3,11]. We think that one of the reasons underlying such confusion lies in differences of the timing of reconstruction. One of the aims of the present paper was therefore to elucidate differences in results between immediate and delayed reconstructions.

For immediate reconstruction we used either a rectus abdominis or a latissimus dorsi musculocutaneous flap, which is rather large. In all six patients who had their upper horizontal planes reconstructed, the grafted bone survived well. This is probably because non-vascularised costal cartilage could be adequately wrapped with a large flap. However, various types of flaps with little soft tissue such as radial forearm and anterolateral thigh flaps were used for delayed reconstruction. Postoperative infection occurred in three of four patients in whom a non-vascularised costal cartilage had been used, although vascularised bone that avoided necrosis of

the flap survived well in all patients. These results indicate a greater possibility of infection if non-vascularised bone cannot be wrapped adequately in a large soft-tissue flap.

Another reason for the high infection rate in non-vascularised bone with delayed reconstruction may be that the operative field is inevitably contaminated by bacterial flora that has already become established in the maxillary defect. Vascularised bone should be selected for reconstruction of the upper horizontal plane for delayed reconstruction, but bacterial contamination of the operative field can be avoided in delayed reconstruction if the maxillary defect is left untouched without reconstruction of the nasal wall or palate. The upper horizontal plane should be reconstructed using only non-vascularised bone together with a soft-tissue free flap. The only patient in whom non-vascularised bone was successfully transferred during delayed reconstruction had such a manipulation.

In addition to the upper horizontal plane, the lower horizontal plane is critical for oronasal competence. Palatal closure is advisable, as patients can usually speak well and eat without dentures [3]. However, palatal closure may reduce prosthetic stability [8], so we think that palatal defects should be closed in younger patients with sufficient residual maxillary teeth for chewing, and an obturator should be used without palatal closure for elderly patients with few residual teeth. Combining the reconstructive concepts of upper and lower horizontal planes, reconstruction should be planned as follows: for immediate reconstruction, the upper horizontal plane should be reconstructed using non-vascularised free bone. Vascularised bone should be used for delayed reconstruction when the nasal or palatal walls are reconstructed and bacterial contamination is expected. This is particularly so when patients are young and with sufficient residual teeth and dentures are not required. However, non-vascularised bone should be used when the maxillary defect has not been touched during operation. When the palate is open dentures are obviously required postoperatively.

For immediate reconstruction all transfers were successful, although there was one arterial thrombosis which was treated by immediate reanastomosis. For delayed reconstruction, however, transferred flaps resulted in necrosis in three of 30 patients. All three necrosed flaps had required interpositional vessel grafting or a radial forearm flap as an interpositional flap, as flap pedicles could not reach the recipient vessels. However, the use of serial flaps is reportedly safe [12,13], even though the risk of necrosis may be higher because double the number of microanastomoses are required. We therefore cannot conclude that the high rate of necrosis in delayed reconstruction results from the use of serial flaps. Another common factor in necrosed flaps was arterial thrombosis, which occurred around postoperative day 4 (relatively late postoperatively) in all cases. The nasal cavity or palate was closed during the operation in each of these three cases. Bacterial contamination is inevitable when the maxillary defect is completely closed, so we think that the cause of the high rate of necrosis of flaps in delayed reconstruction compared with immediate reconstruction involves infection around the pedicles that leads to late vascular thrombosis. To avoid this type of infection, the maxillary defect should be cleaned preoperatively.

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