と報告している。ほかに女性が男性よりも予後良好であり，遺伝性髄様癌の方が散発型より予後良好であるとする報告もある[1]が，女性や遺伝性症例では若年で，病期も早い症例が多いことが影響した結果であるとも考えられる。当科の症例での分析では性別，散発型か遺伝性か，および年齢は予後に明らかな影響は認めなかったが，病理組織学的リンパ節転移の数は重要な予後因子であった。

1984 年，Saad ら[3]は髄様癌切除標本の calcitonin 免疫染色を行い，癌細胞の calcitonin 染色率により予後が異なることを示した。25%未満の細胞しか染色されない calcitonin-poor 腫瘍の 5 年生存率が 52.7%であったのに対し，75%を超える染色率を示した calcitonin-rich 腫瘍のそれは 100%であったという。すなわち，calcitonin 染色率は腫瘍の分化・成熟の程度を反映しており，calcitonin-rich 腫瘍はより分化が良く，進行が遅く予後が良いと考えられた。しかしながら，血液中の calcitonin 濃度は予後因子として単独では有効でないとする報告が多い。これは calcitonin 血中濃度が calcitonin 産生細胞数だけではなく，腫瘍の大きさなどの影響も受けるためであると考えられており，むしろ，予後因子としては CEA 値のほうが有用であるとする報告がある。CEA は primitive な腫瘍マーカーであり，分化が悪く calcitonin 産生能を失った癌細胞から多く産生されると考えられている。

当科における髄様癌腫瘍マーカーの予後因子としての意義の検討でも，生化学的治癒群と非治癒群とで術前 calcitonin 値には有意差がなかったが，術前 CEA 値は非治癒群で有意に高値であった。しかし，術前 CEA 値の cut-off 値の設定を工夫しても，無再発生存率に対する有意差を導くことはできなかった。そこで独自に，術前 calcitonin と CEA の測定値の比を取ることを考案したところ，calcitonin/CEA 比は生化学的治癒群において非治癒群に比べ有意に高値であるばかりでなく，cut-off 値を 10 とすると，10 を超える症例では全例生化学的治癒が得られ，無再発生存率が 100%であったのに対し，10 以下の症例の 5 年無再発生存率は 25%と有意差を認めた。なお，再発症例における calcitonin/CEA 比の最大値は 10.0 (calcitonin 1500pg/ml，CEA 150ng/ml)，無再発症例での最小値は遺伝子検査によって発見された症例の 10.5 で，calcitonin 42pg/ml，CEA 4ng/ml とともに正常値であった。

髄様癌の病期の術前評価において，リンパ節転移の検索は頸部超音波検査によってかなり進歩したとはいえ，縦隔リンパ節転移の診断は容易ではない。さらに遠隔転移の検索のためには肝臓の dynamic CT や新しい核種を用いたシンチグラフィなどが提案されている[7]が，正確な診断は困難であるし，全例に対して行うには cost performance の問題もある。今回考案した calcitonin/CEA 比の測定はいまだ症例数が少なく，観察期間も十分ではないとはいえ，簡便に髄様癌の予後を推測することができ，その値が低い症例には十分な転移検索，拡大切除を行うようにするなど，髄様癌の診断治療において有用性の高い予後因子になり得るものと考えられた。

髄様癌における甲状腺切除範囲については，欧米では散発型であっても甲状腺全摘を勧める意見が強いが，宮内らは RET 遺伝子検索により変異がなく，腫瘍が単発性であれば，腺葉切除にとどめてよいとした[8]。当科の方針もそれに準じており，これまで温存した甲状腺からの再発は経験していない。

髄様癌に対するリンパ節郭清については，転移が認められないものは中心領域の郭清にとどめ，転移がある場合のみに側頸部郭清をするという意見[9]から，全例に同側の保存的頸部郭清を行う意見[10]，さらに全例に両側郭清を行うべきとするもの[11]，これに縦隔郭清を加えるべきだというもの[12]まで様々である。髄様癌のリンパ節転移率は乳頭癌ほどではないが高率であり（散発型で 54～81%），とくに対側頸部リンパ節転移や縦隔リンパ節転移の頻度が高いうえ，乳頭癌と異なりリンパ節転移が重要な予後不良因子であることから，最近の報告には拡大郭清を勧める意見が目立つ[13]。しかし，当科では術前超音波診断によるリンパ節転移の進行度に合わせて術式を拡大するのでよいと考えている。高度のリンパ節転移を伴う症例では拡大郭清により根治できることは少ないといわれている[11]こともあるが，実際，術前画像診断により N0 と診断された 9 例中 8 例には中心領域のみの郭清を行っており，その 8 例中 7 例は pN0 であった。N0 と術前診断された全例で生化学的治癒が得られており再発を認めていない。また，これらの症例の術前 calcitonin/CEA 比はいずれも 10 をこえていた。頸部超音波検査および calcitonin/CEA 比を参考に，リンパ節郭清範囲を縮小することが可能であると考えられた。しかしながら，当科においても縦隔リンパ節再発を 4 例に認めており，今後縦隔 CT をルーチンに行うことも考慮している。

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PROGNOSTIC VALUE OF THE CALCITONIN-TO-CEA RATIO IN MEDULLARY THYROID CARCINOMA

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Serum levels of calcitonin and CEA represent useful tumor markers for medullary thyroid carcinoma (MTC). CEA secretion-rich MTCs are considered more aggressive than calcitonin-rich tumors. We examined the significance of the ratio of serum calcitonin (pg/ml) to CEA (ng/ml) as a prognostic factor for MTC. Between 1986 and 2002, a total of 20 patients with MTC underwent surgery at our institute. Tumor type was sporadic in 13 cases, and hereditary in 7 patients from 3 families. Tumors were recurrent in 5 patients, and the 5-year disease-free survival was 80%. Recurrences occurred in the mediastinum in 4 patients, cervical lymph nodes in 3, and liver in 2. The 2 patients with hepatic recurrence died of the disease, and the 5-year disease-specific survival was 88%. Preoperative calcitonin/CEA ratio ≤ 10 and ≥ 10 pathological metastatic nodes represented significant prognostic factors for disease-free survival. No recurrence was found in 13 patients with biochemical cure (normalization of both serum calcitonin and CEA) after surgery. These 13 patients were the same patients with preoperative calcitonin/CEA>10. The preoperative serum calcitonin/CEA ratio can be used as a prognostic factor for patients with MTC.

SURGICAL MANAGEMENT OF MAXILLECTOMY DEFECTS BASED ON THE CONCEPT OF BUTTRESS RECONSTRUCTION

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Abstract: *Background.* Few published large series have described a surgical approach to maxillary skeletal reconstruction on the basis of the extent of maxillectomy.

Methods. We have reviewed a 10-year experience with 38 consecutive maxillary reconstructions with respect to maxillectomy defects, reconstructive procedures, reconstructed buttresses, and functional and aesthetic outcomes.

Results. Maxillectomy defects were classified into three categories on the basis of the buttress concept. Buttress reconstruction was most frequently performed in category III maxillary defects (56%), followed by category I (50%) and category II (20%). The vascularized composite autograft included the rectus abdominis myocutaneous free flap combined with costal cartilage, and the latissimus dorsi myocutaneous free flap combined with the V-shaped scapula is an effective method for reliable reconstruction of both skeletal and soft tissues.

Conclusions. A critical assessment for skeletal defects and associated soft tissue defects is essential for an adequate approach to solve complex problems in maxillary reconstruction. On the basis of retrospective analysis of this series, a reconstructive algorithm for surgical management of maxillectomy defects is proposed. © 2004 Wiley Periodicals, Inc. *Head Neck* **26:** 247–256, 2004

Keywords: maxillary reconstruction; maxillary buttress; maxillectomy defect; vascularized composite autograft; microsurgical tissue transfer

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Oncologic resection of the maxilla, paranasal sinuses, palate, zygoma, and orbit causes significant functional and aesthetic defects. These may result in collapse of infraorbital and malar composite tissues, several orbital complications, loss of the hemipalate, and difficulty with speech and mastication. The advent of microsurgical techniques has greatly benefited reconstruction of the complex maxillectomy defect; however, some of the problems associated with reconstructive approaches for soft tissue replacement alone remain.[1–3]

At the Hokkaido University Hospital and affiliated hospitals, maxillectomy defects after extensive ablation of tumors have been reconstructed on the basis of the principles of repair involving an important concept of maxillary buttress reconstruction.[4] The midfacial structure consists of

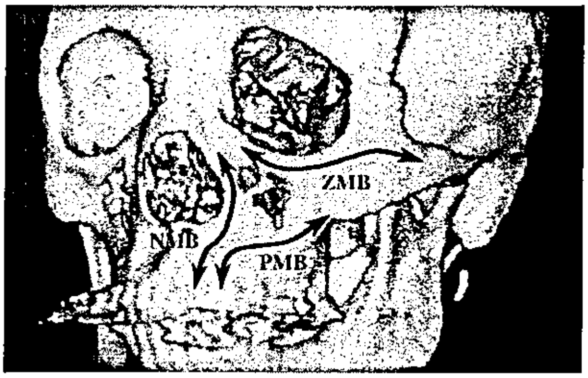


FIGURE 1. Three maxillary buttresses in the surgical management of maxillary skeletal defects. ZMB, zygomaticomaxillary buttress; PMB, pterygomaxillary buttress; NMB, nasomaxillary buttress.

three principal maxillary buttresses: the zygomaticomaxillary (ZMB), pterygomaxillary (PMB), and nasomaxillary buttresses (NMB). The ZMB extends from frontal process of maxilla along the inferior ridge of the orbit to the zygomatic process of the frontal bone and laterally to the zygomatic arch. The PMB extends from the alveolar ridge anterior to the pterygoid plate of the sphenoid bone. The NMB extends from the anterior maxillary alveolus along the piriform aperture to the nasal process of the maxilla (Figure 1). Restoration of these buttresses is a rational approach to obtain the most effective reconstruction of complex maxillectomy skeletal defects.

Herein the senior author's experience with 38 consecutive patients is represented. The objective of this study was to review these reconstructive cases with respect to maxillectomy defects, reconstructive procedures, reconstructed buttresses, and functional and aesthetic outcomes. A reconstructive algorithm for surgical management of maxillectomy defects on the basis of the concept of buttress reconstruction was also devised.

PATIENTS AND METHODS

From October 1992 to July 2002, 38 patients with maxillectomy defects were reconstructed by the senior author (YY). The mean patient age at the time of the surgery was 58 years, with a range from 26 to 78 years. There were 28 men and 10 women. On pathologic examination of the primary tumor, squamous cell carcinoma was the most common tumor type (76%).

Maxillectomy Defects. Maxillectomy defects were grouped into one of three categories on the basis of our retrospective assessment for anatomic sites of resection. Category I included limited maxillectomy and subtotal maxillectomy defects. In this category, the anterior and/or medial walls of the lower maxilla, including the palate, are mainly removed with preservation of the orbital inferior ridge and floor. According to the buttress concept, the PMB and partial NMB are ablated (Figure 2A). Category II included orbitomaxillectomy and orbitozygomatic maxillectomy defects. In this category, the anterior and medial walls of the upper maxilla, including the orbital contents (orbital exenteration), are mainly removed with preservation of the palate. The malar region, including the zygomatic arch, is occasionally resected in an orbitozygomatic maxillectomy. According to the buttress concept, the ZMB and partial NMB are ablated (Figure 2B). Category III included total maxillectomy and extended to total maxillectomy defects. In this category, the maxilla is completely removed without preservation of the orbital inferior ridge and floor and the palate. The orbital contents (orbital exenteration), malar region including zygomatic arch, and/or facial skin and/or mimetic muscle are occasionally resected in an extended total maxillectomy. According to the buttress concept, the ZMB, PMB, and NMB are ablated (Figure 2C). In this series, the maxillary defects of six patients (16%) were defined as category I, of five patients (13%) as category II, and of 27 patients (71%) as category III (Table 1).

Reconstructive Procedures. In this series, 19 patients (50%) underwent only soft tissue reconstruction. The reconstructed sites of soft tissue included the palatal roof, lateral wall of the nasal cavity, eye socket, and facial skin. The rectus abdominis myocutaneous free flap was the most commonly used in 13 patients, followed by the radial forearm free flap in 3 patients. Twelve of 13 rectus abdominis myocutaneous/muscle free flaps were used for the patients with a category III maxillectomy defect. The temporalis muscle flap and temporoparietal fascial flap were mainly applied for a category II maxillectomy defect. On the other hand, the remaining 19 patients (50%) underwent simultaneous reconstruction of skeletal and soft tissues. The reconstructed sites of skeletal tissue included the ZMB, PMB, and NMB on the basis of the concept of buttress reconstruction. Vascularized composite autograft was used for 17 of 19 patients with simultaneous reconstruction of skeletal and soft tissues. In the early stage of this series, three-dimensionally contoured pieces of titanium mesh were used in two patients. In this series, neither nonvascularized bone nor

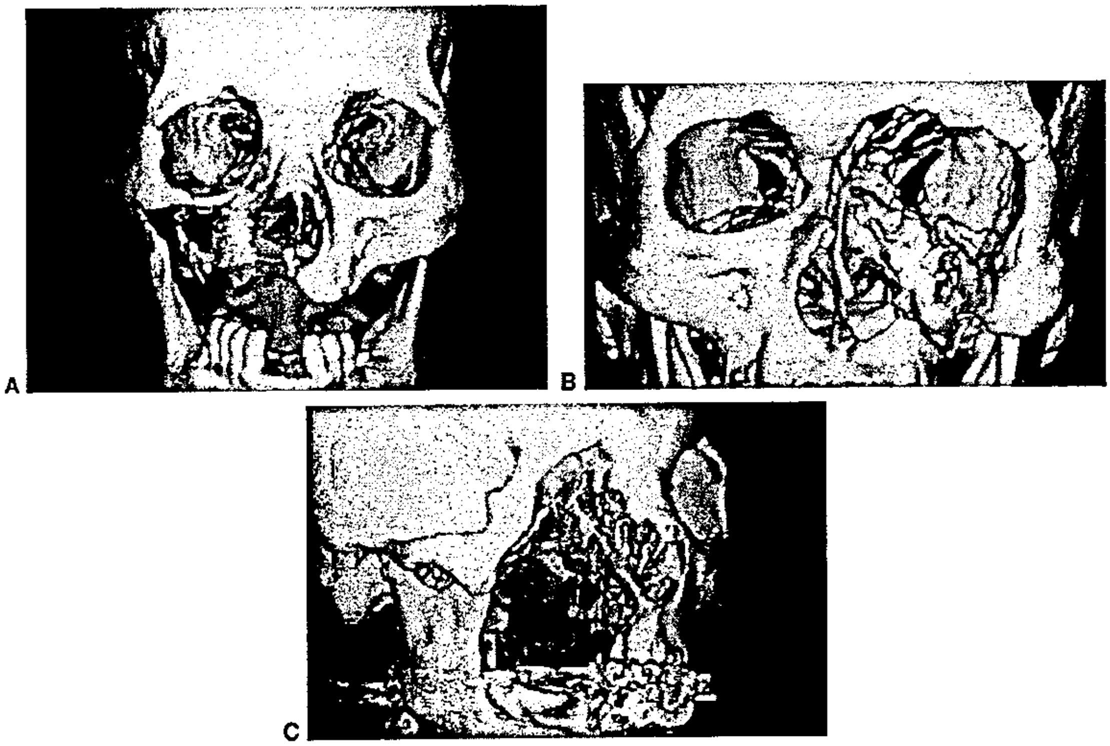


FIGURE 2. **(A)** Category I of maxillectomy defect in three-dimensional CT scan. PMB and NMB are removed. Limited maxillectomy and subtotal maxillectomy are included in this category. **(B)** Category II of maxillectomy defect in three-dimensional CT scan. ZMB and NMB are removed. Orbitomaxillectomy and orbitozygomaticomaxillectomy are included in this category. **(C)** Category III of maxillectomy defect in three-dimensional CT scan. All three buttresses are removed. Total maxillectomy and extended total maxillectomy are included in this category.

cartilage graft was used for buttress reconstruction. Occasionally, a free bone graft was additionally placed at the orbital floor in the patient, with preservation of the orbital contents. The rectus abdominis myocutaneous free flap combined with costal cartilage[5] was the most common composite autograft (seven patients) (Figure 3A), followed by the latissimus dorsi myocutaneous free flap combined with scapula (six patients), the scapular free flap combined with scapula (two patients) (Figure 3B), and the latissimus dorsi myocutaneous free flap combined with scapula and rib[6] (one patient) (Figure 3C) (Table 2).

RESULTS

Immediate reconstruction was carried out in 25 patients (66%) and secondary reconstruction in the remaining 13 patients (34%). The microsurgical

Table 1. Summary of categories of maxillectomy defects and buttress reconstruction.

Maxillary defect	No. of patients	Reconstructed buttress: ZMB	No.	PMB	No.	NMB	No.	None
Category I	6 (16%)	Not required		Scapula; lateral border; fibula	1 1	Scapula; lateral border	1	3
Category II	5 (13%)	Costal cartilage	1	Not required		—	0	4
Category III	27 (71%)	Scapula; medial border; costal cartilage; rib; titanium mesh	6 5 1 2	Scapula; lateral border	7	Scapula; medial border	1	12

Six patients underwent reconstruction of two buttresses (ZMB and PMB), and one patient underwent reconstruction of three buttresses (ZMB, PMB, and NMB) in category III.

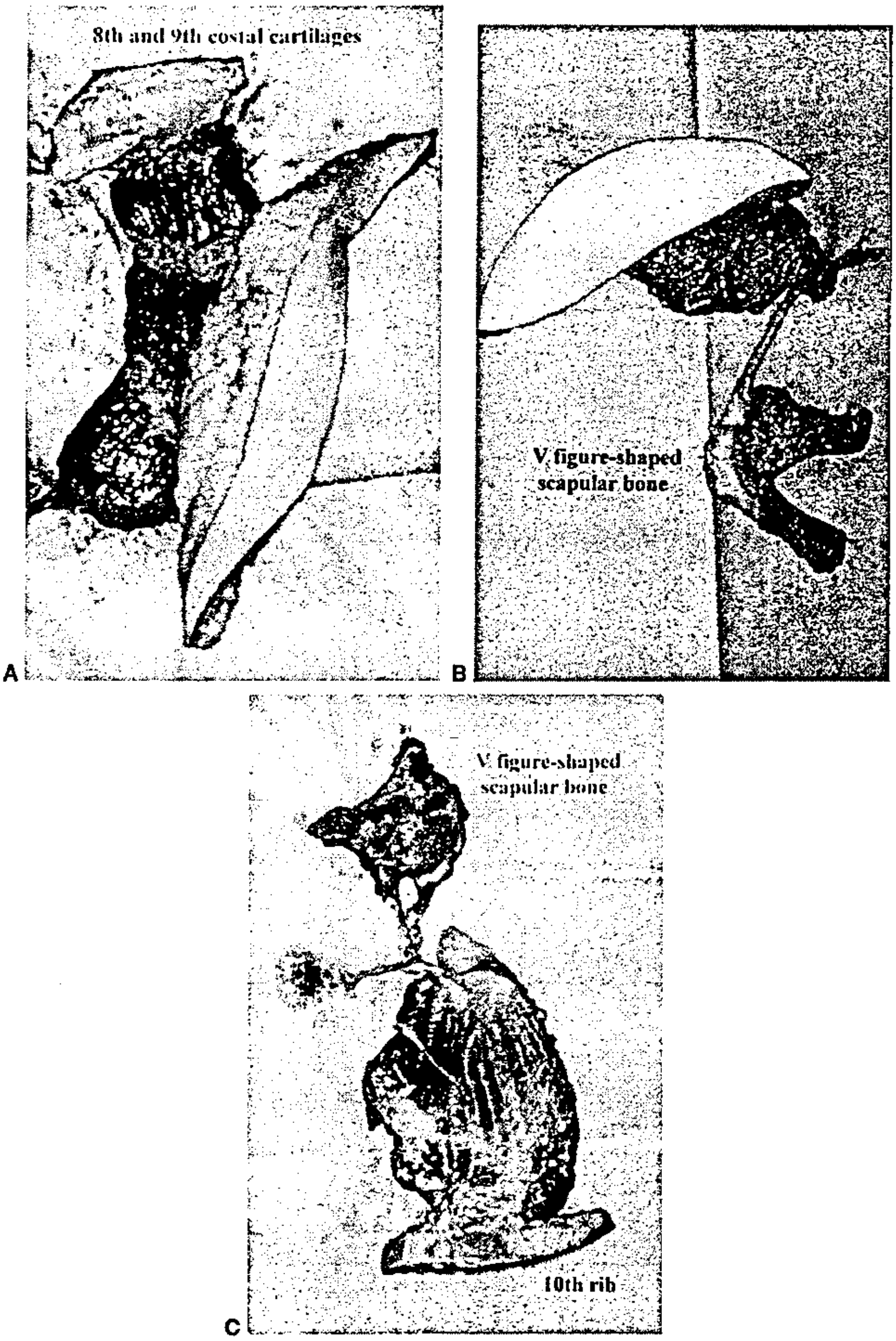


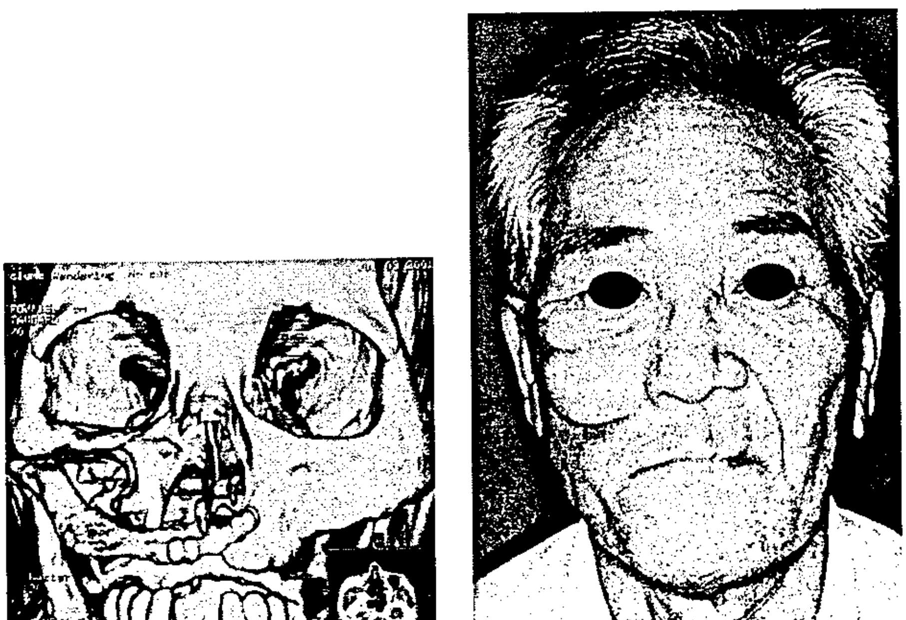
FIGURE 3. (A) The rectus abdominis myocutaneous free flap combined with costal cartilage. The vascular pedicle of this composite graft is the deep inferior epigastric vascular system, and the included eighth and ninth costal cartilages are supplied from the vascular connection between the eighth intercostal and deep epigastric vascular systems. **(B)** The latissimus dorsi myocutaneous flap combined with V-shaped scapular bone. The vascular pedicle of this composite graft is the thoracodorsal vascular system, and the included scapula is nourished by the angular branch. **(C)** The latissimus dorsi myocutaneous flap combined with V-shaped scapular bone and tenth rib. The vascular pedicle of this composite graft is the thoracodorsal vascular system. The scapula is nourished by the angular branch, and the included tenth rib is supplied from the communicating perforators from the latissimus branch of thoracodorsal to the tenth intercostal vascular system. The infraspinous fossa of the scapula was removed later, and the bony piece was used for reconstruction to the orbital floor.

Table 2. Reconstructive procedures in 38 patients with maxillectomy defect.

Reconstruction of soft tissue only	No. of patients	Reconstruction of skeletal and soft tissues	No. of patients
RAMFF	13	Vascularized composite autograft	
RFFF	2	RAMFF with CC	7
RFFF and TFF	1	LDMFF with S	6
TMF	1	SFF with S	2
TMF and TFF	1	LDMFF with S and R	1
MFF	1	OFFF	1
		Combination of titanium mesh	
		RAMFF	1
		SFF	1

Abbreviations: RAMFF, rectus abdominis myocutaneous free flap; RFFF, radial forearm free flap; TFF, temporoparietal fascial flap; TMF, temporalis muscle flap; MFF, median forehead flap; RAMFF with CC, rectus abdominis myocutaneous flap combined with costal cartilage; LDMFF with S, latissimus dorsi myocutaneous free flap combined with scapula; SFF with S, scapular free flap combined with scapula; LDMFF with S and R, latissimus dorsi myocutaneous free flap combined with scapula and rib; OFFF, osteocutaneous free flap of fibula; SFF, scapular free flap.
**RAMFF with CC failed in one patient.*

tissue transfer was used for 35 patients (92%). No flap failures were reported in the 34 patients with free flaps and three patients with pedicled flaps (97%). One rectus abdominis myocutaneous free flap combined with costal cartilage developed total necrosis because of arteriovenous thrombus 5 days postoperatively. In the patient, the palatal surface was covered with skin graft. In an average follow-up of 18 months (range, 4–108 months), even though four of 19 patients with buttress reconstruction received postoperative irradiation, no obvious absorption of the grafted bone and cartilage was noted in any of the patients. However, two patients had three-dimensionally contoured pieces of titanium mesh, and three patients had titanium plates and screws for fixing the grafted bone or cartilage at the reconstructed ZMB region that showed persistent cutaneous fistulas. The fistulas healed completely after the alloplastic materials were removed.



A B

FIGURE 4. The latissimus dorsi myocutaneous free flap combined with scapula for category I of maxillary defect. **(A)** The right PMB was reconstructed by lateral border of the scapula. **(B)** Postoperative appearance at 6 months. Palatal roof, lateral wall of nasal cavity, and buccal skin on the right side were replaced by the latissimus dorsi myocutaneous flap. Debulking of the flap is scheduled.

Reconstructed Buttresses. In category I maxillary defects, buttress reconstruction was carried out in three of six patients (50%). PMB was reconstructed with the scapula and fibula in two patients (Figure 4) and NMB with the scapula in one patient. The remaining three patients did not undergo buttress reconstruction. In category II maxillary defects, buttress reconstruction was carried out in one of five patients (20%). ZMB was reconstructed with costal cartilage in one patient. The remaining four patients did not undergo buttress reconstruction. In category III maxillary defects, buttress reconstruction was carried out in 15 of 27 patients (56%). ZMB was reconstructed in 14 patients. The medial border of the scapula was used for six patients and the costal cartilage for five patients (Figure 5), the rib for one patient, and titanium mesh for two patients. The PMB was reconstructed in six patients with the lateral border of the scapula. The NMB was reconstructed in one patient with the scapula. This series included six patients with reconstruction of two buttresses (ZMB and PMB) using aV-shaped scapula (Figure 6) and one patient with all three buttresses (ZMB, PMB, and NMB) using V-shaped scapulas and ribs (Figure 7). The remaining

FIGURE 5. The rectus abdominis myocutaneous free flap combined with costal cartilage for category III maxillary defect. **(A)** The left ZMB was reconstructed by eighth and ninth costal cartilages. **(B)** Postoperative appearance at 8 months. Palatal roof, lateral wall of nasal cavity, and eye socket on the left side were replaced by the rectus abdominis myocutaneous flap.

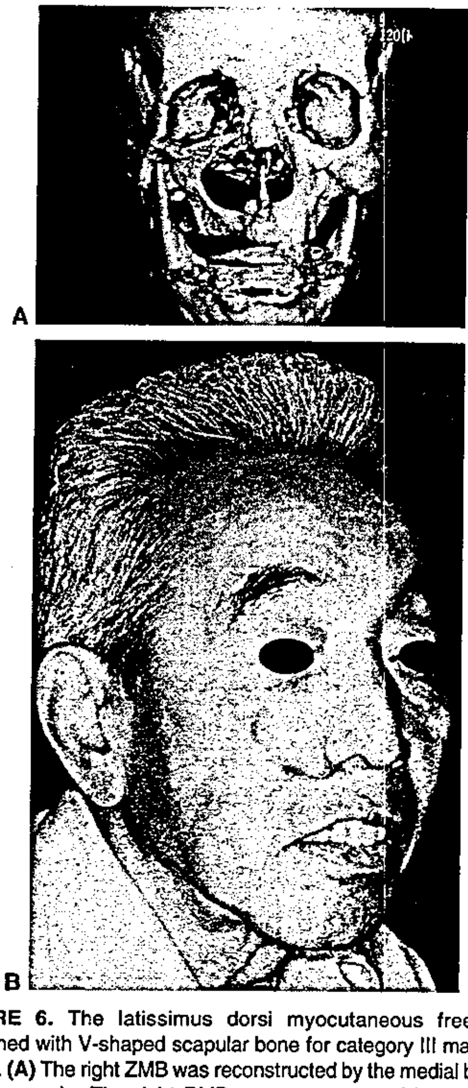


FIGURE 6. The latissimus dorsi myocutaneous free flap combined with V-shaped scapular bone for category III maxillary defect. **(A)** The right ZMB was reconstructed by the medial border of the scapula. The right PMB was reconstructed by the lateral border of the scapula. **(B)** Postoperative appearance at 25 months. Palatal roof, lateral wall of nasal cavity, and buccal skin on the right side were replaced by the latissimus dorsi myocutaneous flap.

12 patients did not undergo buttress reconstruction (see Table 1).

Functional and Aesthetic Outcomes. In category I and III maxillary defects (33 patients) in which the palate was included, the PMB was removed; 28 patients underwent palatal roof reconstruction with the transferred flap, and all of them had intelligible or better speech. The patients under-

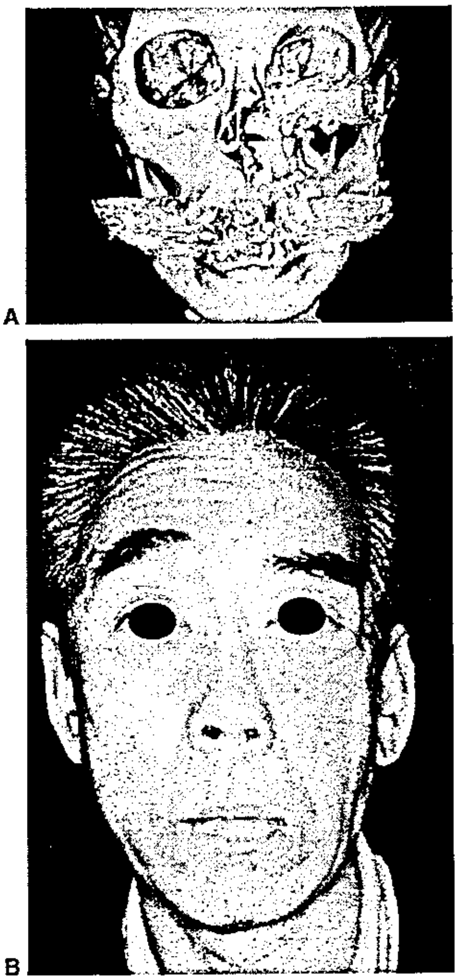
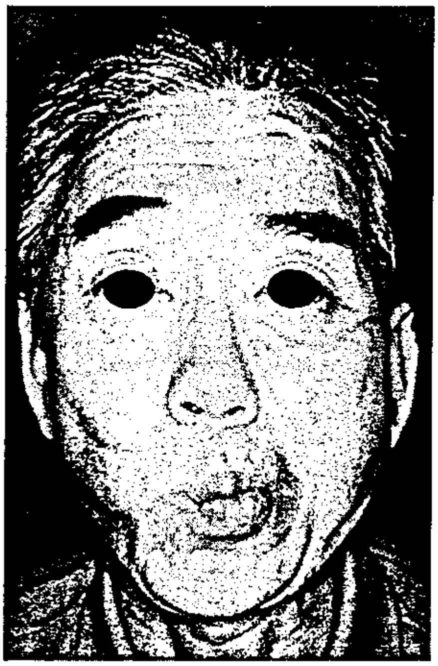


FIGURE 7. The latissimus dorsi myocutaneous free flap combined with V-shaped scapular bone and rib for category III maxillary defect. **(A)** The left ZMB was reconstructed by the tenth rib with one osteotomy. The left PMB was reconstructed by the lateral border of the scapula. The right NMB was reconstructed by the medial border of the scapula. **(B)** Postoperative appearance at 13 months. Palatal roof, lateral wall of nasal cavity, and buccal skin on the left side were replaced by the latissimus dorsi myocutaneous flap. Facial palsy caused by injury of facial nerve trunk and removal of buccal mimetic muscles on the left side was noted.

FIGURE 8. **(A)** The patient with asymmetry of buccal region caused by facial palsy and atrophy of muscular portion of the transferred flap at 32 months postoperatively. **(B)** Secondary surgical revision using deepithelized anterolateral thigh free flap combined with the reinnervated rectus femoris muscle flap was carried out. **(C)** Improved functional and aesthetic result was obtained (same patient as Figure 7).



C

FIGURE 8. (continued)

going reconstruction of the lateral wall of the nasal cavity (nasal lining) by the transferred flap did not have discomfort from nasal obstruction. Nine patients who had PMB reconstruction by vascularized bone graft were able to eat a regular diet with a useable dental prosthesis. However, most patients without PMB reconstruction were restricted to a soft/pureed diet because of poor stability of their dental prosthesis. In category II and III maxillary defects (32 patients) in which the orbital floor including the ZMB was removed, the orbital contents were preserved in 12 patients. Nine patients with reconstruction of the orbital floor, including ZMB by vascularized bone or cartilage graft, did not have malposition of eye globe and diplopia. However, two patients with removal of the titanium mesh grafted for ZMB reconstruction and one patient with a fascia lata graft for orbital floor reconstruction had mild to severe vertical diplopia. The remaining 20 patients with category II and III maxillary defects underwent resection of the orbital contents followed by simultaneous reconstruction of the eye socket with the transferred flap. Only seven patients with preservation of upper and lower eyelids were able to wear an ocular prosthesis.

Secondary surgical revisions were required in seven patients to improve their facial appearance. Debulking of the flap, Z-plasty for the flap marginal scar, shaving of the grafted bone, and blepharoplasty on the upper eyelid were performed in six patients. In addition, one patient underwent a free flap surgery for soft tissue augmentation and reanimation of facial palsy (Figure 8).

DISCUSSION

With the development of a vascularized composite autograft using a microsurgical technique, reconstruction of extensive maxillary defects has been achieved to a high level of functional and aesthetic results.[4,5,7–21] However, few published large series describe a surgical approach to maxillary skeletal reconstruction based on the extent of resection of the maxillary bone.[19] In 1998, we introduced the concept of buttress reconstruction for restoration of maxillary skeletal defects.[4] The concept was derived from the principles of anatomic restoration of the vertical and horizontal maxillary buttresses in the surgical management of complex midfacial fractures.[22,23] First, in this retrospective study, the maxillectomy defects were analyzed according to removal of maxillary buttresses because understanding the skeletal defect of maxilla is the first key point in approaching effective maxillary reconstruction.[24,25] Maxillectomy defects of this series were divided into three categories on the basis of anatomic sites of resection. Compared with the classification system for maxillectomies from Memorial Sloan-Kettering Cancer Center, a category I maxillary defect corresponds to type I and II defects, category II to type IV, and category III to type IIIa and IIIb.[19] From the reconstructive surgeon's standpoint, PMB is a main buttress to be reconstructed in a category I maxillary defect. In case of extensive resection of buccal soft tissue including mimetic muscle and skin, the NMB should be reconstructed to prevent the superior and posterior deviation of the alar base. The ZMB is the main buttress to be reconstructed in a category II maxillary defect, especially with extensive resection of the zygomatic process and arch. However, most category II cases do not require skeletal reconstruction. In category III maxillary defects, the ZMB and PMB are the main buttresses to be reconstructed. Reconstruction of the ZMB including the orbital floor is essential for prevention of malposition of the eye globe for preservation of the orbital contents. ZMB reconstruction is also important to provide a good contour for the malar prominence. PMB reconstruction provides sufficient support for fitting a dental prosthesis. In case of extensive resection of buccal soft tissue, the PMB and NMB should be reconstructed to prevent the superior and posterior deviation of the alar base and oral commissure. Accordingly, reconstruction of all three buttresses is considered for the patient with a category III maxillary defect with extensive resection of zygomatic process and arch and buccal soft tissue.

We have demonstrated that a vascularized composite autograft is the most common physiologic material of choice for complex maxillary defects.[4] In skeletal reconstruction with alloplastic materials or nonvascularized bone and cartilage, displacement, infection, absorption, or fistula formation remains a potential problem during the long-term follow-up period. Moreover, in patients who receive preoperative/postoperative radiotherapy, persistent irradiated injury compromises the reconstructed region. Especially in the reconstructed ZMB area, gravity, scar contracture, and tightness of the overlying soft tissue lead to a higher incidence of such complications. With these considerations in mind, several reconstructive techniques using vascularized composite autografts have been mainly used for maxillary reconstruction in our institute. In reconstruction of the ZMB, vascularized eighth and ninth costal cartilage connected to the rectus abdominis myocutaneous flap was used for five (40%) of 15 patients, and the medial border of the scapula connected to the latissimus dorsi myocutaneous or scapular flap was used for six patients (40%). The rectus abdominis myocutaneous flap combined with costal cartilage is a useful tool for restoration of one buttress (ZMB) and a midfacial soft tissue defect. In reconstruction of the PMB, the lateral border of the scapula connected with the latissimus dorsi myocutaneous or scapular flap was used for eight (89%) of nine patients. We consider that the lateral border of the scapula is well tolerated for restoration of the PMB because it has enough volume to provide reliable stability for fitting a dental prosthesis. The latissimus dorsi myocutaneous or scapular flap combined with the V-shaped scapula is good for restoration of two buttresses (medial border for ZMB and lateral border for PMB) and midfacial soft tissue defects. The central space of the V-shaped scapula also allows placement of the bulk of the transferred flap. In reconstruction of all three buttresses, the latissimus dorsi myocutaneous free flap combined with the V-shaped scapular bone and rib is a versatile technique to manage such a complex skeletal defect.

Reconstruction of both skeletal and soft tissues of maxillectomy defects is ideal; however, various factors affect the determination of the reconstructive method. The patient's age, associated diseases, degree of advanced carcinoma, and request for skeletal reconstruction from the surgical oncologist are important issues to be evaluated preoperatively. In this series, buttress reconstruction was performed most frequently for category III (56%) maxillary defects, followed by category I (50%) and category II (20%). The necessity of buttress reconstruction increases according to the extent of

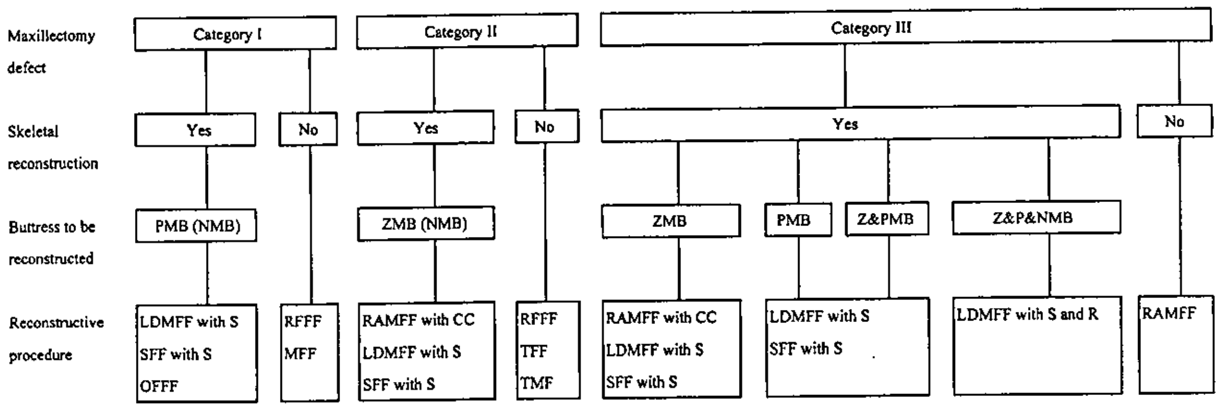


FIGURE 9. A reconstructive algorithm for surgical management of maxillectomy defects. ZMB, zygomaticomaxillary buttress; PMB, pterygomaxillary buttress; NMB, nasomaxillary buttress; RAMFF, rectus abdominis myocutaneous free flap; RFFF, radial forearm free flap; TFF, temporoparietal fascial flap; TMF, temporalis muscle flap; MFF, median forehead flap; RAMFF with CC, rectus abdominis myocutaneous flap combined with costal cartilage; LDMFF with S, latissimus dorsi myocutaneous free flap combined with scapula; SFF with S, scapular free flap combined with scapula; LDMFF with S and R, latissimus dorsi myocutaneous free flap combined with scapula and rib; OFFF, osteocutaneous free flap of fibula; SFF, scapular free flap. V-shaped scapula is applied for reconstruction of two or three buttresses.

maxillary resection. Finally, in a retrospective analysis of this series, we were able to generate a reconstructive algorithm for the surgical management of maxillectomy defects (Figure 9). We advocate that a critical assessment of skeletal defects and associated soft tissue defects after various types of maxillectomies is essential for an adequate approach in solving complex reconstructive problems. On the basis of this assessment, the most effective reconstructive technique should be applied individually. Furthermore, to improve postoperative functional and aesthetic outcomes, one should not hesitate using secondary surgical revisions including free flap transfer in this challenging field of reconstructive head and neck surgery.

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A new technique of microvascular suturing: the chopstick rest technique☆

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KEYWORDS
Microsurgical anastomosis; Chopstick rest; Microsuture

Summary With the conventional techniques of tying knots during microvascular anastomosis or neural suturing, time may be lost due to various reasons. The loose end of the suture often falls down into the operative field and gets stuck to the surrounding tissues. In the process of retrieving the suture, the surrounding tissues can be picked up together with the suture. When the posterior wall technique [Br J Plast Surg 34 (1981) 47, Plast Reconstr Surg 69 (1982) 139, Microsurgery 8 (1987) 22, J Reconstr Microsurg 15 (1999) 321] is used, the loose end of the suture may be stuck to the backside of the vessel and may be hard to grab. In order to avoid those problems, a new way of tying a microsuture was developed. By avoiding contact of the loose end of the suture to the surrounding tissue at any point during tying, the microvascular anastomosis can be performed quicker and more efficiently.

Performing a microvascular anastomosis or neural suturing with small microsutures (smaller than 9.0) is still a very time consuming act. Installing an optical device as a microscope, preparing the microsurgical operative field and preparing the vessels for anastomosis takes up time. During the process of suturing and tying the microsuture, a lot of time is often lost by the loose end of the suture falling into the moist and sticky operative field. Once the loose end attaches to the operative field, it can be hard to retrieve it, and in doing so the surrounding tissues may be picked up together with the suture. In other cases where the posterior wall technique is used, the loose end often gets stuck to the vessels themselves. It can be tricky to find and retrieve the loose end.

The main difference between the chopstick rest technique and conventional techniques is that the loose end of the microsuture is always held by the forceps and the needle holder and never falls into the operating field thus never touches the

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Figure 1 After tying the first knot, the loose end of the suture is to the left held by a forceps and the long end of the suture is to the right, held by the needle holder.

surrounding tissues. This article describes the operative technique and tips for training.

Operative technique

The tying of the knot of this new microsurgical technique can be divided into three different steps.

The first knot. This is performed in the traditional way. This can be a single or double tied knot as determined by the habits of the surgeon. With the usual techniques the loose end of the suture will be dropped in the operative field. With this new technique the loose end needs to be held by the forceps.

The second knot. To facilitate the explanation of this technique we are starting from a position where, after tying the first knot, the loose end of the suture is to the left, held by a forceps and the long end of the suture is to the right, held by the needle holder (Fig. 1). At first, the needle holder is brought to the left whilst making a twisting manoeuvre over an angle of 90-180° to the left. Hereby a small loop is created in the long end of the suture (Fig. 2). Important is that at the end of this movement, the tip of the curved needle holder is turned upwards to be able to provide a temporary ledge on which the loose end of the suture can be placed (Fig. 3). After placing this loose end on the tip of the needle holder the forceps is brought

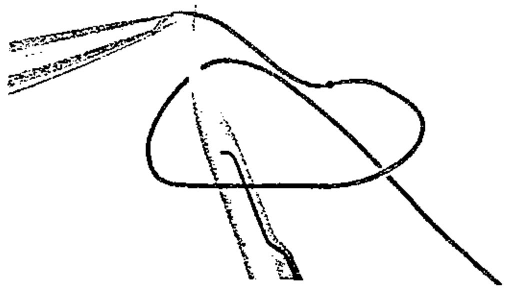

Figure 3 The tip of the curved needle holder is turned upwards to be able to provide a temporary ledge on which the loose end of the suture can be placed.

under the needle holder (Fig. 4) and through the loop to grasp the loose end of the suture (Fig. 5). Tension is placed on both ends of the suture and a flat knot is made on top of the first knot (Fig. 6).

The third knot. Meanwhile, after finishing the second knot, the needle holder with the long end is moved to the right and the forceps with the loose end is moved to the left (Fig. 7). This part is then moved to the left, creating a gentle curve in the loose end. The needle holder with the long end is moved to the right, twisting the long end around the forceps. The needle holder together with the long end is positioned against the loose end of the suture providing gentle pressure to it to be able to immobilise the loose end (Fig. 8). Then the loose end is released by the forceps (Fig. 9). The forceps is brought over the needle holder and the loose end is once again retrieved by the forceps (Fig. 10). Once again gentle traction is provided on both ends of the suture and the knot is tied (Fig. 11). More knots can be placed on top of each other if necessary. Further tying is a sequence of repeating the second and the third knot.

Training model

Before using this tying method in clinical

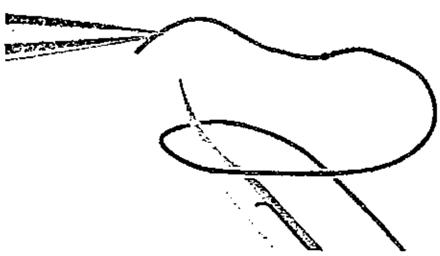

Figure 2 The needle holder is brought to the left whilst making a twisting manoeuvre over an angle of 90-180° to the left. Hereby a small loop is created in the long end of the suture.

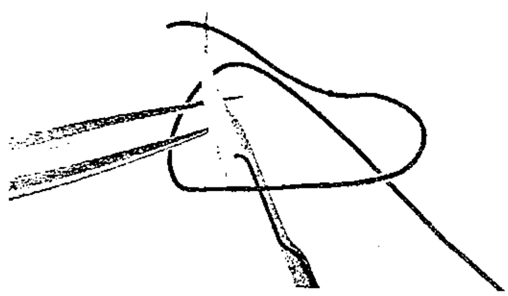

Figure 4 After placing this loose end on the tip of the needle holder the forceps is brought under the needle holder.

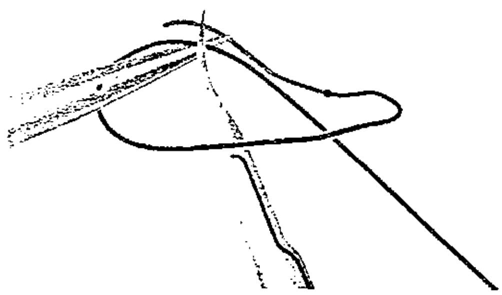

Figure 5 The forceps is brought through the loop to grasp the loose end of the suture.

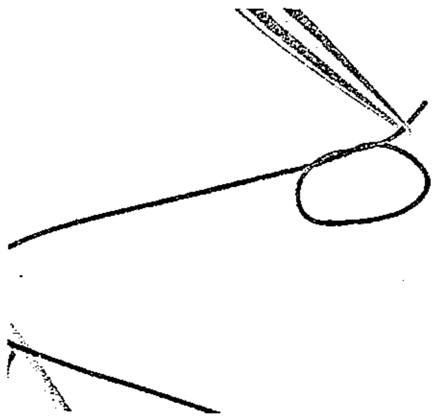

Figure 6 Tension is placed on both ends of the suture and a flat knot is made on top of the first knot.

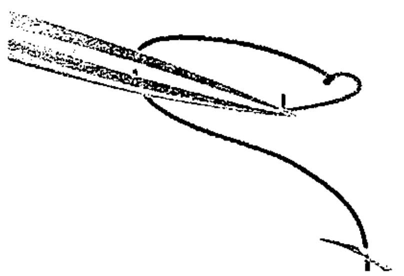

Figure 7 The needle holder with the long end is moved to the right and the forceps with the loose end is moved to the left.

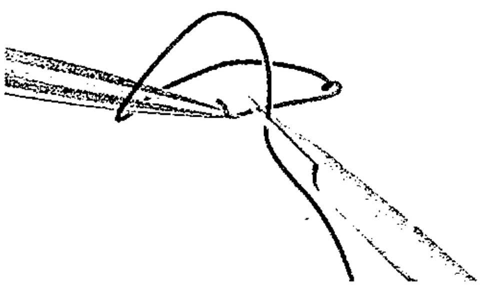

Figure 8 The needle holder with the long end is moved to the right, twisting the long end around the forceps. The needle holder together with the long end is positioned against the loose end of the suture providing gentle pressure to it to be able to immobilise the loose end.

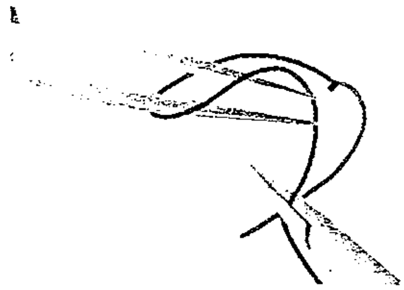

Figure 9 The loose end is released by the forceps.

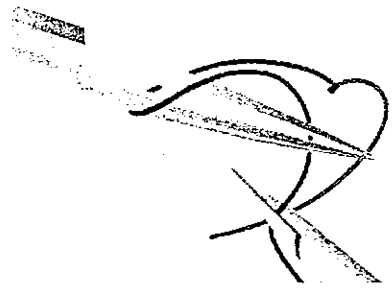

Figure 10 The forceps is brought over the needle holder and the loose end is once again retrieved by the forceps.

Figure 11 Once again gentle traction is provided on both ends of the suture and the knot is tied.

procedures, an easy training model can be used to obtain more experience. This is done by using a 9.0 nylon suture and a simple gauze (Fig. 12). The gauze is cheap and widely available and it simulates movements and tension of normal living tissue. The 9/0 nylon is probably the easiest suture to train with although also 10/0 and 11/0 can be used. The rigidity of the 9/0 nylon makes it an easier suture to practice with.

Discussion

The untied suture technique,[5] the sleeve anastomosis,[6-8] the posterior wall technique[1-4] and the running suture technique[9] have all been reported as safe and successful methods to perform microvascular anastomosis. New devices such as the Microvascular Coupler[10] and VCS clips[11] have been

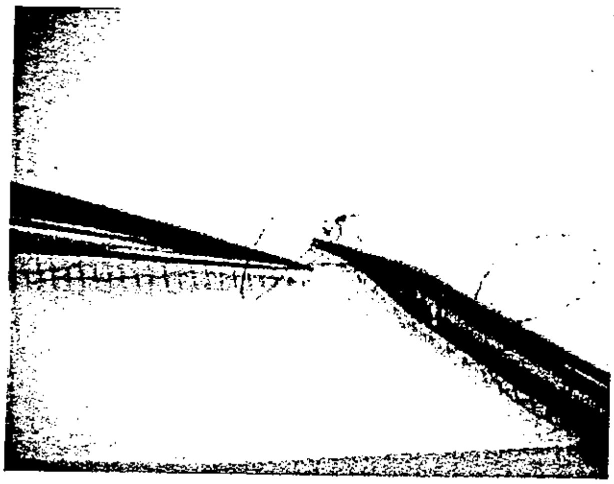

Figure 12 The training of this technique is done by using a 9.0 nylon suture and a simple gauze.

developed to shorten the operating time. High costs and inherent disadvantages of these devices have not made them unanimously popular.

Also the conventional way of placing interrupted sutures on small calibered vessel walls have their own problems. The main problem of interrupted suturing and tying is that the loose end of the suture will quickly stick to the surrounding tissues or the vessel wall. Attempts to retrieve the suture are often time consuming. It is exactly at this point that the technique presented in this paper distinguishes itself.

The most important advantage of our technique is saving the time wasted in trying to retrieve the loose end of the suture. As is described in the operative technique part, using our technique enables smoother and faster microvascular anastomosis when placing interrupted sutures on anterior vessel walls.

The technique is even more beneficial in posterior wall technique. Sometimes the operator has no choice but to do posterior wall anastomosis first. In these situations the posterior wall technique is always useful. However, the problem with the posterior wall method is; there the loose end cannot only stick to the operating field but also to the posterior wall of the vessel. Using this technique avoids the loose end of the suture getting behind the vessel wall and as a result saves the time wasted in searching and retrieving the loose end. Thus our technique can be applied to every interrupted suture from any angles around the vessel.

There are a number of advantages to the technique including operating time reduction. Additionally, the technique is extremely simple. Also the training model can be used quite easily. Therefore it is very beneficial and economical when practicing this technique.

Key for success in this technique is the shape of the needle holder. A slightly curved needle holder needs to be held with its tip up to provide a small platform for the loose end to rest on. Even in narrow and deep cavities when a curved needle holder is kept upright, this instrument can be used to perform the chopstick rest technique smoothly (Fig. 13).

In contrast, this obviously will not work with a straight needle holder or another forceps. Therefore, the loose end of the suture sometimes slip off these two instruments (Fig. 14).

For this reason, we recommend only the use of the curved needle holder for any kinds of operation fields, to carry out the Chopstick Rest Technique effectively and smoothly.

Nevertheless, it requires a change of habits if one is used to tying the knot with the needle holder and to hold on to the long end of the forceps. However, this technique is easy to learn. Handling of both

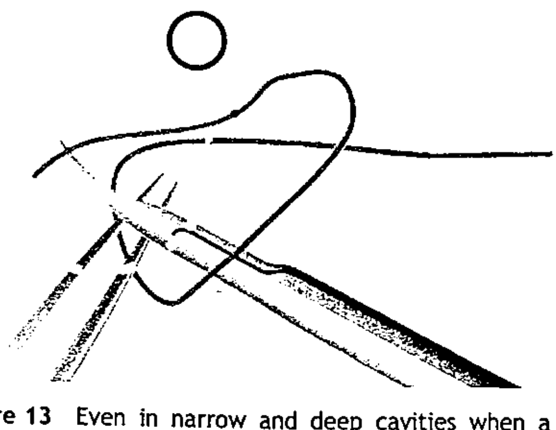

Figure 13 Even in narrow and deep cavities when a curved needle holder is kept upright, this instrument can be used to perform the chopstick rest technique smoothly.

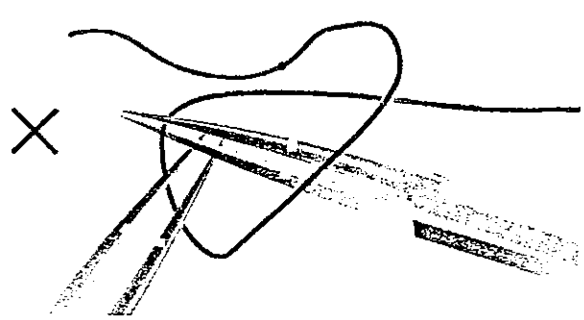

Figure 14 In difficult situations, the loose end of the suture slip off the straight needle holder or another forceps.

ends of the suture is totally opposed to what most microsurgeons are used to today. The loose end is held by the forceps while the long end is held by the needle holder. This requires a change of style that might not always be easy.

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Prefabricated osteocutaneous flapの臨床応用

—Free muscle vascularized pedicle (MVP) bone flapによる上下顎および歯槽堤再建—

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Key words：prefabricated osteocutaneous flap 上顎 下顎 歯槽堤

はじめに

新冨らは血管束の付着した少量の筋体をcarrierとして二次的にvascularizeされるmuscle vascularized pedicle flap（以下，MVP flapと略す）を開発し，1982年にその臨床応用例を報告した[14]。この概念を拡大すれば，皮膚以外にも，骨，軟骨，腱，神経などいかなる組織でも，新たにMVPにより二次的にvascularizeし，再建に利用することが可能である。

われわれはすでに，下腹壁動静脈を栄養血管とする腹直筋弁により二次的にvascularizeし，分層植皮により再上皮化し，人工歯根を植立したfree MVP iliac crest flapを用いて，機能的な上顎歯槽堤再建を行った症例を報告した[6]。今回はfree MVP bone flapによる上下顎および歯槽堤再建を行った19例を分析し，MVP bone flapの臨床的価値とその有用性を考察する。

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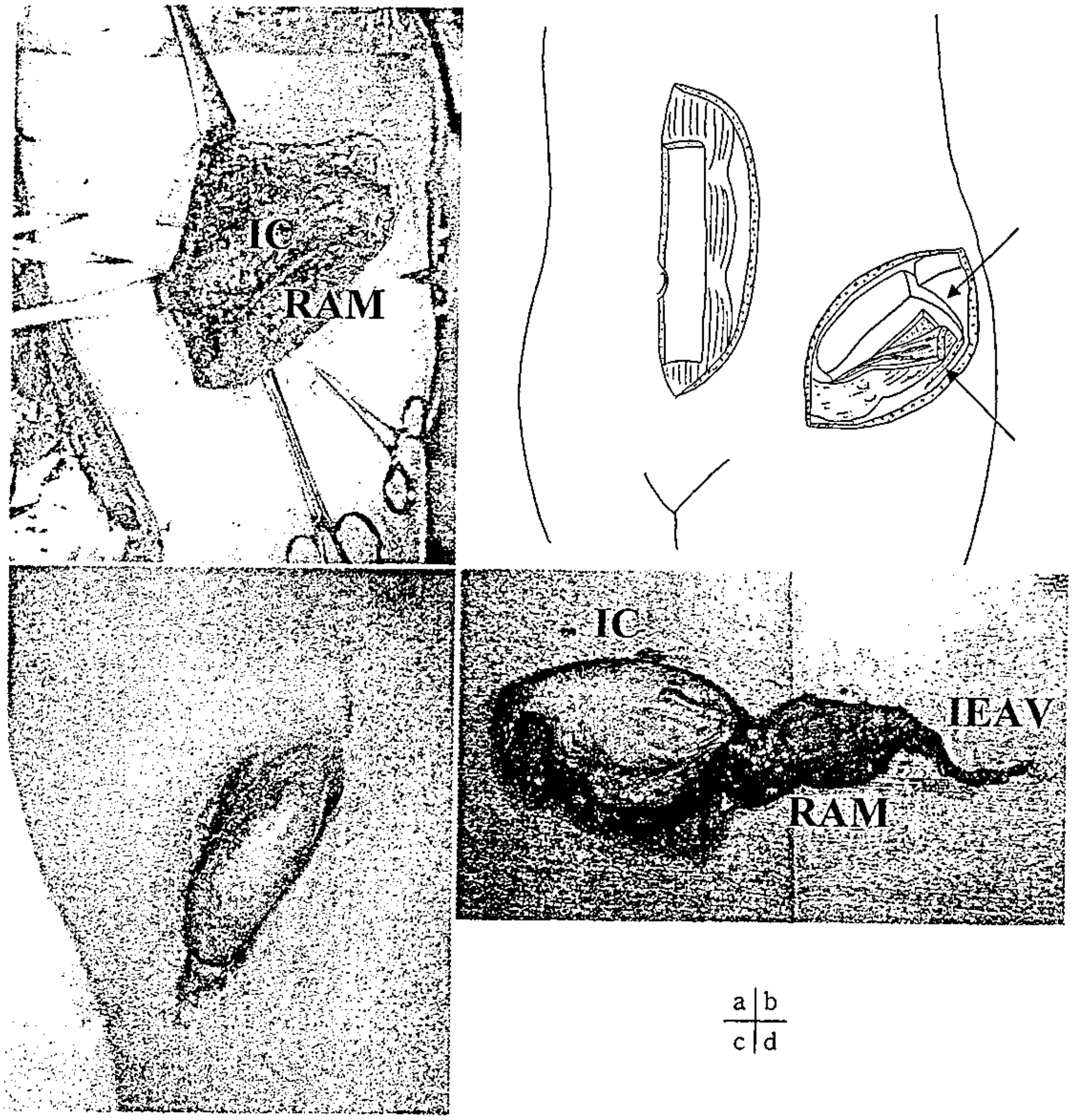
I 手術手技

手術はvascular implantation，bony delay，flap transferの3段階に分かれる。Vascular implantationとしてまず，筋体の一部をその栄養血管とともに挙上し，再建に利用する骨に移植する（図1-a，b）。筋体の一部をcarrierとして，その栄養血管により骨を二次的にvascularizeするのが目的である。Revascularizationを効率的よく促進させるために，筋体は皮質を除去し髄質を露出させた骨表面へワイヤーで確実に固定する（図1-a，b）。ついで，筋肉をcarrierとして利用した，新たな栄養血管による骨の血行支配を優位にすべく，vascular implantationの約1カ月後に，1ないし2回の骨切りをdelay（bony delayと呼んでいる）として行う（図1-b）。歯槽堤再建を同時に行う場合には，将来の歯槽堤相当部位の骨膜上への分層植皮を，vascular implantationあるいはbony delayと同時に行う（図1-c）。最後のbony delayの約2週後，骨を完全に離断し，MVP bone flapをfree flapとして（図1-d）上顎ないし下顎の欠損部へ移植，プレート固定し，顔面ないし頚部で微小血管吻合を行い，血流を再開させる。



(a) Vascular implantation
下腹壁動静脈(IEAV)を血管柄とする腹直筋弁(RAM)を，腸骨稜(IC)の皮質を削除した海綿質に移植し，ワイヤー固定する。
(b) Bony delay
Vascular implantation 後約1カ月で，腸骨に delay としての骨切り(→)を行う。
(c) 骨膜への STSG
将来の歯槽堤となる腸骨稜には，vascular implantation あるいは bony delay と同時に，分層植皮を行う。
(d) Flap transfer
Bony delay 後約2週で，MVP iliac crest free flap を腸骨より完全に切り離し，微小血管吻合により上下顎および歯槽堤欠損部に移植する。

図 1　Free MVP iliac crest flap の手術手技

(Igawa HH, et al: Functional alveolar ridge reconstruction with prefabricated iliac crest free flap and osseointegrated implants after hemimaxillectomy. Plast Reconstr Surg 102: 2420-2424, 1998 より一部引用修正)