대한성형외과학회지. 제 38 권, 제 6 호
J Korean Soc Plast Reconstr Surg
Vol. 38, No. 6, 719 - 724, 2011



# 전산화단층촬영 혈관조영술을 이용한 얼굴동맥의 수술 전 평가

김주학[1,5] · 강낙헌[1] · 이인호[2] · 서영준[3,5] · 양호직[5,6] · 송승한[5,7] · 오상하[1,4,5]

충남대학교 의과대학 성형외과학교실[1], 영상의학과학교실[2], 피부과학교실[3], 의학연구소[4], 충남대학교병원 임상해부학연구회[5], 을지대학교 의과대학 성형외과학교실[6], 서울중앙신체검사소[7]

## Preoperative Evaluation of the Facial Artery Using Facial Angio Computed Tomography

Joo Hak Kim, M.D.[1,5], Nak Heon Kang, M.D.[1], In Ho Lee, M.D.[2], Young Joon Seo, M.D.[3,5], Ho Jik Yang, M.D.[5,6], Seung Han Song, M.D.[5,7], Sang Ha Oh, M.D.[1,4,5]

Departments of [1]Plastic & Reconstructive Surgery, [2]Radiology, [3]Dermatology, [4]Research Institute for Medical Science, College of Medicine, Chungnam National University, [5]Clinical Anatomy Institute, Chungnam National University Hospital, Daejeon; [6]Department of Plastic and Reconstructive Surgery, College of Medicine, Eulji University, Daejeon; [7]Seoul Military Manpower Administration, Seoul, Korea

**Purpose:** Previous studies of the facial artery have shown significant anatomical variability in this region. The vascular anatomy of the region is considered unreliable in predicting the ideal pedicle. Preoperative imaging has been suggested as a means of improving preoperative awareness, with Doppler ultrasound as useful tools. Multi-detector row angiographic computed tomography (angio CT) is a significant improvement, providing non-invasive operator-independent details of the vascular anatomy. This tool was used to perform an *in vivo* anatomical study of the facial artery, demonstrating the usefulness of facial angio CT in planning the facial reconstruction.

**Methods:** Eleven consecutive patients underwent facial angio CT of the facial vasculature with the anatomical details of the facial artery assessed.

**Results:** Facial angio CT could demonstrate the size and course of the facial vasculature, particularly the facial artery.

**Conclusion:** The vascular anatomy of the facial artery is highly variable, and thus there is a role for preoperative imaging. Facial angio CT can demonstrate cases where there is an aberrant or non-preferred anatomy, or select the method of a facial reconstruction.

Received March 30, 2011
Revised June 28, 2011
Accepted June 29, 2011

**Address Correspondence:** Sang-Ha Oh, M.D., Department of Plastic & Reconstructive Surgery, Chungnam National University Hospital, 640 Daesa-dong, Jung-gu, Daejeon 301-721, Korea. Tel: 82-42-280-7387/Fax: 82-42-280-7384/E-mail: djplastic@cnu.ac.kr

**Key Words:** Facial artery, Facial angio CT, Facial reconstruction

## I. INTRODUCTION

The midface, which includes the nose, lower eyelid and medial canthal area, is the most prominent area of the face and is extremely vulnerable to trauma and skin cancer. Reconstruction of the midface is difficult because of its anatomic and functional complexity, donor site morbidity and poor esthetic results. Skin graft and local flaps have limitations, such as color, texture and donor site morbidity. In these cases, axial pattern flaps based on the facial artery are more useful.[1]

For a successful reconstruction, it is essential to know the precise anatomy of the facial artery. Since it shows highly anatomical variations, its termination and course is not always symmetrical or constant and types of major-branch distribution of the facial artery was also examined in detail by Niranjan et al.[2] The high anatomical variation of the facial artery limits the use of this flap, and increases the surgical stress and potential for complications with the procedure. Conventional catheter angiography and Doppler are useful tools for examining the vascular network but they have some limitations.

Recently, multi-detector row angiographic computed tomography (angio CT) has emerged as a significant improvement, providing non-invasive operator-independent details of the vascular anatomy. At our institution, facial angio CT has been shown to provide accurate information on the vascular location, size and course in the planning of axial flaps in the facial region. Moreover, this imaging technique has been shown to reduce the surgery time and complications. This study evaluated the ability of this technology to demonstrate the *in vivo* anatomy of the facial artery, as well as the utility of this technique in the planning of a midface reconstruction.

## II. MATERIALS AND METHODS

Between 2010 and 2011, 11 consecutive patients (22 facial arteries, 7 males and 4 females) were considered for a midfacial reconstruction with flaps based on the facial artery assisted by facial angio CT (Table I). After obtaining written informed consent from all patients, a preoperative facial angio CT study was performed for surgical planning using a 64-detector-row CT Somatom Sansation model (Syngo CT 2007S) with the following parameters: 120 kVp, 80-120 mA, 512 × 512 matrix.

All scans were obtained after the intravenous administration of 120 mL of nonionic iodinated contrast with a concentration of 370~400 mgL/ml (Iomeron 370~400). The volumetric data acquired was then used to reconstruct images with a slice width of 1.3 mm and a reconstruction interval of 0.6 mm for 21 faces. The resulting complete set of reconstructed images was transferred automatically to a computer workstation, which generates images in multiple planes and in 3-dimensional volume-rendered images. A 3-dimensional reconstruction of the faces was performed to locate the course of facial artery precisely. The axial flaps based on the facial artery were selected according to its location, course and size.

## III. RESULTS

Facial angio CT could show the facial artery with high resolution and accuracy, demonstrating vessel size, location and course (Fig. 1). There were no allergic reactions or adverse effects after administering the non-ionic iodinated contrast agents, and no complications as a result of the use facial angio CT. In all cases, bifurcation and branches of the facial arteries were well visualized. In 19 of the 22 facial arteries (86%), the facial artery terminated as the angular artery at the medial canthus (Niranjan's classic type, Table I), in two of 22 facial arteries (9%), the facial artery terminated as lateral nasal vessel (Niranjan's nasal type). Rest of facial artery (5%) was descend from the angle of the mouth toward the infraorbital foramen, then runs transversely toward the nose, where it branches to the bridge and ends eventually as the angular artery at the medial canthus (Niranjan's long course type). In cases of asymmetric facial arteries, the vascular pedicle that was terminated at the medial canthal area, was located near the nasolabial fold, and had a larger diameter was chosen. The diameter of facial artery was from 1.9 mm to 3.5 mm in this study.

If the pedicle is deviated laterally or shows a tortuous pathway, it can be detected before surgery and carefully dissected during surgery. There were no major compli-

**Table I.** Clinical Analysis of the Patients

| Patient | Age/ Sex | Etiology | Location | Defect size ($cm^2$) | Niranjan's subdivision of facial artery (Rt./Lt.) | Diameter of facial artery (Rt./Lt.,mm) | Operative method | Complications /secondary procedure |
|---|---|---|---|---|---|---|---|---|
| 1 | 80/M | BCC* | Ala, nose | 1.5 × 2.0 | Classic/Classic | 2.7/2.0 | RF† | Flap bulkiness/ debulking |
| 2 | 84/M | BCC | Nasal tip | 0.8 × 0.8 | Classic/Nasal | 2.0/2.5 | RF | None |
| 3 | 51/F | BCC | Nasal tip | 1.5 × 1.2 | Long course/Nasal | 2.0/1.7 | RF | None |
| 4 | 52/M | BCC | Lower lid, Rt. | 2.5 × 2.0 | Classic/Classic | 3.5/3.2 | RF | None |
| 5 | 44/M | BCC | Ala, nose | 3.0 × 3.5 | Classic/Classic | 2.4/2.2 | RF | None |
| 6 | 68/M | BCC | Ala, nose | 2.0 × 2.0 | Classic/Classic | 1.9/2.1 | RF | None |
| 7 | 74/F | BCC | Nasal tip | 2.3 × 2.5 | Classic/Classic | 1.9/2.2 | RF | None |
| 8 | 69/M | BCC | Upper lip | 3.0 × 2.8 | Classic/Classic | 2.5/2.1 | NLFOMF+ | None |
| 9 | 64/F | BCC | Upper lip | 3.8 × 2.5 | Classic/Classic | 2.2/2.4 | NLFOMF | None |
| 10 | 72/M | BCC | Lower lid, Lt. | 1.8 × 2.0 | Classic/Classic | 2.5/2.3 | RF | None |
| 11 | 58/F | BCC | Ala, nose | 2.0 × 1.5 | Classic/Classic | 2.1/2.4 | DNF‡ | None |

*:BCC, basal cell carcinoma; †:RF, retroangular flap; +:NLFOMF, nasolabial fold orbicularis oris flap; ‡:DNF, dorsal nasal flap.

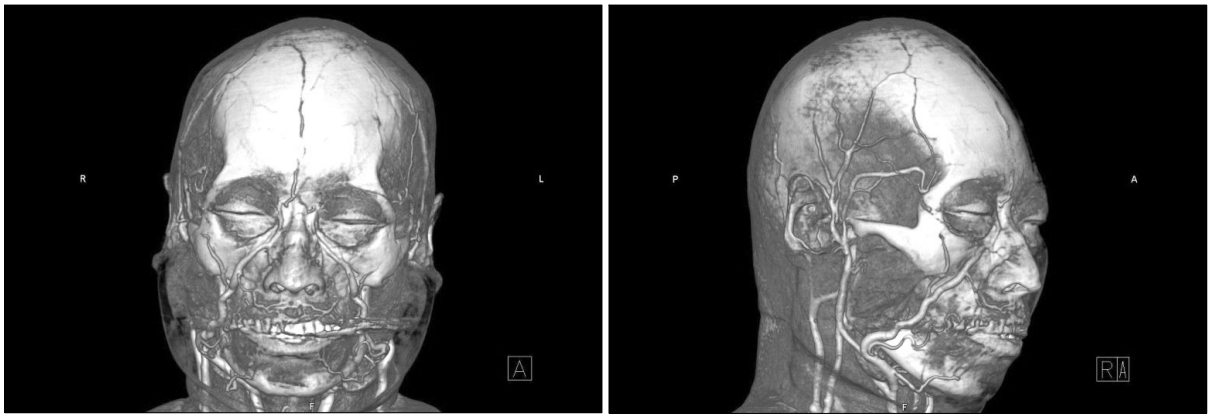

**Fig. 1.** Preoperative 3D reconstruction with angio-CT scan focusing on facial artery. Angio CT shows size, location and course of facial artery with high resolution and accuracy.

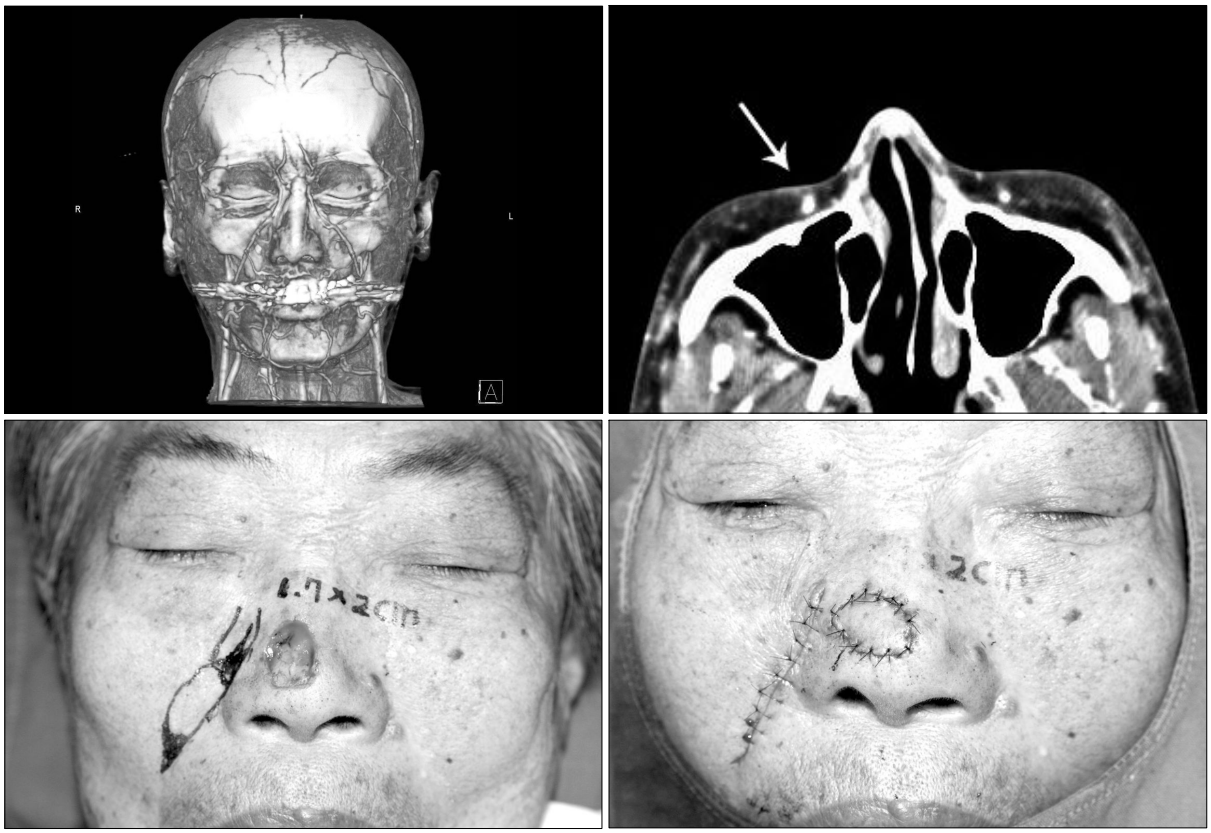

**Fig. 2.** Case 1. A 65-year-old male with nasal tip defect caused by a basal cell carcinoma resesction. (Above, left) Preoperative Angio-CT shows anatomic information of both facial arteries. Rt. angular artery is closer to the nasolabial fold. (Above, right) The diameter of the right angular artery is larger than the left side. The arrow indicates the right angular artery. (Below, left) Preoperative photo. (Below, right) The nasal defect was reconstructed successfully using a right retroangular flap.

cations, such as wound disruption, hematoma, infection and flap necrosis. On the other hand, flap bulkiness was observed one case. Secondary debulking operation was performed 6 months after surgery.

Case 1

A 65-year-old male patient underwent ablation of a basal cell carcinoma on the nasal tip. On the preoperative facial angio CT, the left side of the pedicle was deviated more laterally from the nasolabial fold than the right side, and

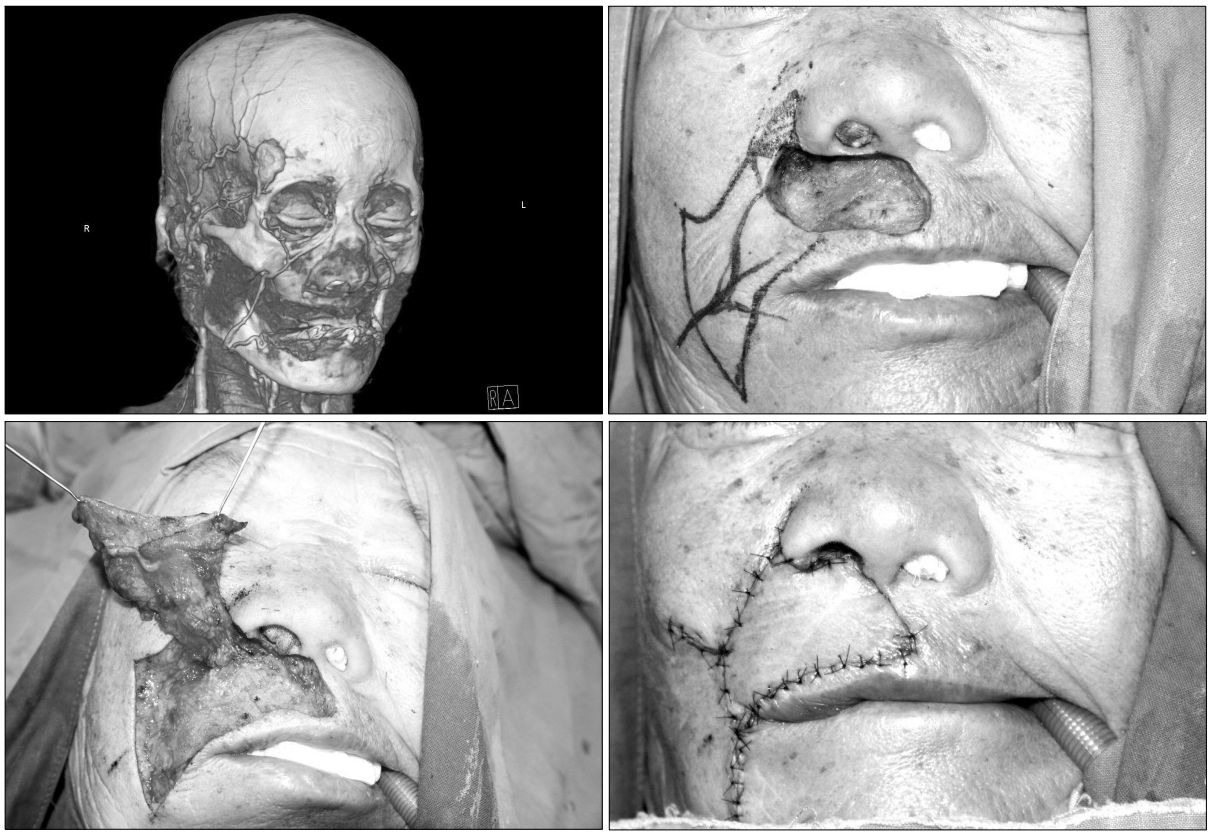

**Fig. 3.** Case 2. A 69-year-old male. (Above, left) Preoperative Angio-CT evaluation of the right angular artery of the facial artery. (Above, right) Large defect of the upper lip caused by a basal cell carcinoma resection. (Below, left) Nasolabial orbicularis oris myocutaneous flap elevation. (Below, right) The upper lip defect was reconstructed successfully.

showed a larger diameter at the coronal view. A successful reconstruction with a retroangular flap from the right side was performed (Fig. 2).

Case 2

A 69-year-old male patient underwent ablation of a basal cell carcinoma on the right upper lip resulting in a 3.8 × 2.5 cm defect. Since it was impossible to reconstruct with a local flap, an axial flap based on the facial artery was planned. The preoperative evaluation indicated no variations in the facial artery and confirmed that the pedicle had terminated at the medial canthal area. A nasolabial fold orbicularis oris myocutaneous flap was designed and elevated, the large defect area of the upper lip was reconstructed successfully (Fig. 3).

## IV. DISCUSSION

The causes of midfacial defects include traffic accidents, trauma and skin cancer, etc. A midfacial defect < 2 cm can be repaired with a local flap, such as Limburg flap, bilobed flap and dorsal nasal flap. In general, there are limitations regarding the size of a defect that can be closed using a local flap. These local flaps covering more than 2 cm can result in a dog ear deformity on the donor site.[3] The forehead flap can be used for large defects but a 2-stage operation is necessary, and this flap is thick and requires defatting.[4] The nasolabial flap has many advantages for a midface reconstruction but has disadvantages for nasal reconstruction, particularly the nasal tip and dorsum, because of the limitations of the rotation arc.[5] In these cases, facial artery based island flaps are often used, such as retroangular flap,[6] nasolabial orbicularis oris myocutaneous flap,[7] and island composite nasal flap.[3] For successful results, it is important to have accurate anatomical information on the vascular pedicle.

In general, the facial artery divides into 4 major branches; submental artery, inferior labial artery, superior labial artery and angular artery. The facial artery enters the face at the lower border of the mandible anterior to the masseter muscle. The artery runs upward and forward

tortuously toward the angle of the mouth then on to the alar base, where it courses along the lateral side of the nose to terminate as the angular facial artery at the inner canthus of the eye. The angular artery near the nasolabial area lies deep in the zygomaticus minor muscle and zygomaticus major muscle but superficial to the levator labii superioris muscle, lateral slips of the levator labii superioris alaeque nasi muscle, and levator anguli oris.[1]

On the other hand, the anatomical structures of the facial arteries vary. Niranjan et al. dissected 50 facial arteries in 25 adults preserved cadavers and they described five types of facial artery distribution. In 68% of the dissections the facial artery terminated as the angular artery at the medial canthus (classic type), in 26% it terminated as a lateral nasal vessel (nasal type), it only 4% did it terminates as an superior labial artery at the upper lip (labialis superior type), The remainder were either alar type (terminated in the alar base, 2%) or long course type (the facial artery ascends from the angle of the mouth toward the infraorbital foramen, then runs transversely toward the nose, where it branches to the bridge and ends eventually as the angular artery at the medial canthus, 10%).[2] Some reports showed that the facial artery is symmetrical in 68%, terminated in an angular facial vessel in 68%, a lateral nasal vessel in 26% and the alar base in 2%.[2] For a midface reconstruction, the popular reconstructive options include a retroangular flap and nasolabial orbicularis oris myocutaneous flap based on the angular artery. Nevertheless, the above methods are not available if the termination of facial artery is the superior labial artery (Niranjan's labialis superior type)(Fig. 4). For this reason, an individual precise preoperative evaluation of the vascular anatomy of the facial artery, such as the location, course and termination, is highly desirable for improving surgical planning and execution. Conventional catheter angiography is considered the gold standard for mapping the major vessels, identifying variant trifurcation arterial anatomy or atherosclerotic disease, but the limitations include its invasive nature and potential morbidity.[8,9] The use of preoperative duplex ultrasound to identify the location of perforator termination in the skin is routine in many centers but ultrasound cannot accurately predict the origin and perforator type and has high inter-observer variability.[10,11] ECD (Echo Color Doppler) is used to map the location and theoretical size of the perforators, which has been described preoperatively by Zhou et al. and Koshima et al.[12,13] Some of the data on the use of ECD is controversial. Operator dependence, false positives in detection of the perforating vessels have been reported in the literature.[14] Doppler is a handy and inexpensive tool for examining the flow velocity and resistivity of the vessels. Nevertheless, operator dependence, false positives in the detection of perforating vessels, and the amount of time that a study takes for the hospital staff and patients has been reported. Furthermore, the information cannot be reproduced so the procedure must be repeated by the radiologist.

Among the last generation of angiographic diagnostic techniques, angio CT has emerged as an outstanding noninvasive operator-independent option. Angio CT defines a technique that combines the technology of a conventional CT scan with that of traditional angiography to create detailed images of the blood vessels in the body. Although conventional angiography requires an intra-arterial injection, angio CT only requires an intravenous injection, and is substantially less invasive. Furthermore, higher level visualization of fine vessels can be achieved with advanced post-processing protocols. These facial angio CT findings have had a strong impact on surgery. In preoperative planning for an axial flap based on the facial artery, facial angio CT has allowed the surgeon to choose between the right and left-side flap, or eventually to abandon this flap in favor of other reconstructive options.

A nasal tip defect can be reconstructed by both sides of a retroangular flap based on the facial artery. The correct flap to use can be decided bu the size of the pedicle, donor location close to the nasolabial fold, and tortuousness. In addition, if the facial artery ends at the superior labial artery, it can be early detected by a facial angio CT examination. Preoperative plans can be made with other options for a midface reconstruction such as a dorsal nasal flap instead of a facial artery based axial flap (Fig. 2).

In a real setting, surgeons examine the anatomy of the facial artery, check for size and anomalous courses, and begin the dissection. In the case of inappropriate pedicles, the other side flap or another flap can be chosen. Of course, a suboptimal decision in reconstruction might expose the patient to unnecessary scaring, tissue dissection, and in the end prolonged surgery. Ultimately, facial angio-CT can save considerable time during surgery, without an extensive overview looking for the facial artery. There was no failure of the flap after facial angio CT and the surgical findings always correlated with the preoperative imaging.

The radiation exposure associated with facial angio CT (up to 10 m S per patient) must be weighed against the benefits of this imaging modality. The financial cost

varies between institutions but is certainly a consideration. Nevertheless, this technique is tolerated well by the patients because it is simple and fast.

## V. CONCLUSION

The vascular anatomy of the facial artery is highly variable, and thus there is a role for preoperative imaging. Facial angio CT can demonstrate the size, location, course and termination of facial artery, and can identify cases where there is an aberrant or non-preferred anatomy, and select the favorable flap site for harvest. Overall, facial angio CT is a highly promising, useful tool for mapping the facial vasculature.

## REFERNCES


1. Seo YJ, Hwang C, Choi S, Oh SH: Midface reconstruction with various flaps based on the angular artery. *J Oral Maxillofac Surg* 67: 1226, 2009
2. Niranjan NS: An anatomical study of the facial artery. *Ann Plast Surg* 21: 14, 1988
3. Tellioglu AT, Tekdemir I, Saray A, Eker E: Reconstruction of proximal nasal defects with island composite nasal flaps. *Plast Reconstr Surg* 115: 416, 2005
4. Ullmann Y, Fodor L, Shoshani O, Rissin Y, Eldor L, Egozi D, Ramon Y: A novel approach to the use of the paramedian forehead flap for nasal reconstruction. *Plast Reconstr Surg* 115: 1372, 2005
5. Hagan WE, Walker LB: The nasolabial musculocutaneous flap: clinical and anatomic correlations. *Laryngoscope* 98: 341, 1988
6. Kang NH, Song SH, Lee SR, Oh SH, Seo YJ: Retroangular flap for midface reconstruction. *J Korean Soc Plast Reconstr Surg* 33: 531, 2006
7. Takatoshi Y, Katsunori Y, Satoshi U, Yukimasa S: Functional and Aesthetic Reconstruction using a Nasolabial orbicularis oris myocutaneous flap for large defects of the upper lip. *Plast Reconstr Surg* 103: 1624, 1997
8. Kessler P, Wiltfang J, Schultze-Mosgau S, Lethaus B, Greess H, Neukam FW: The role of angiography in the lower extremity using free vascularized fibular transplants for mandibular reconstruction. *J Craniomaxillofac Surg* 29: 332, 2001
9. Young DM, Trabulsy PP, Anthony JP: The need for preoperative leg angiography in fibula free flaps. *J Reconstr Microsurg* 10: 283, 1994
10. Futran ND, Stack BC Jr, Payne LP: Use of color Doppler flow imaging for preoperative assessment in fibular osteoseptocutaneous free tissue transfer. *Otolaryngol Head Neck Surg* 117: 660, 1997
11. Giunta RE, Geisweid A, Feller AM: The value of preoperative Doppler sonography for planning free perforator flaps. *Plast Reconstr Surg* 105: 2381, 2000
12. Zhou G, Qiao Q, Chen GY, Ling YC, Swift R: Clinical experience and surgical anatomy of 32 free anterolateral thigh flap transplantations. *Br J Plast Surg* 44: 91, 1991
13. Koshima I, Fukuda H, Yamamoto H, Moriguchi T, Soeda S, Ohta S: Free anterolateral thigh flaps for reconstruction of head and neck defects. *Plast Reconstr Surg* 92: 421, 1993
14. Blondeel PN, Beyens G, Verhaeghe R, Van Landuyt K, Tonnard P, Monstrey SJ, Matton G: Doppler flowmetry in the planning of perforator flaps. *Br J Plast Surg* 51: 202, 1998