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The Free Scapular Flap for Head and Neck Reconstruction

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The free scapular flap is a versatile flap for soft tissue and bony reconstruction of the head and neck. It has a very reliable blood supply and is easy to harvest. In this paper, we present our cumulative experience with the use of five cutaneous flaps and 31 osteocutaneous flaps. AM J OTOLARYNGOL 11:318–327. © 1990 by W.B. Saunders Company.
Key words: mandibular reconstruction, osteocutaneous, free flap.

The surgical ablation of extensive head and neck neoplasms frequently results in large defects of bone and soft tissue. In the past, the reconstruction of these defects was limited by inadequate vascularity of the soft tissue due to previous irradiation or to fibrosis resulting from surgery. Local contamination combined with inadequate vascularity contributed significantly to the failure of the more traditional methods of mandibular reconstruction.[1,2]

With the advent of microsurgical free tissue transfer techniques, the reconstructive surgeon can reliably reconstruct large composite defects in the head and neck region without concern for recipient site vascularity. Freed from the restraint of a vascular pedicle, the transfer of distant donor site tissues by microvascular techniques has opened the frontier to more esthetic and functional reconstruction.

Clinical microvascular surgery was pioneered in 1972 with the transfer of a groin flap to the lower extremity by Daniel and Taylor.[3] Several reports followed by plastic surgeons as well as otolaryngologists-head and neck surgeons, documenting the use of various free flaps in head and neck reconstruction. The scapular free flap is one of the more versatile flaps for this purpose and is currently our osteocutaneous flap of choice for mandibular reconstruction. The scapular flap was initially described as a cutaneous free flap. The anatomy was described by Saijo in 1978[4] and the first report of its clinical use was by dos Santos in 1980.[5] Teot et al.[6] suggested the scapula as a possible source of revascularized bone in 1981. The free scapular osteocutaneous flap was first described for mandibular reconstruction by Swartz et al in 1986.[7] We have subsequently reported our experience with this flap for head and neck reconstruction.[8,9]

In this report, we evaluate our cumulative experience since 1986 with the free scapular flap. Thirty-six consecutive cases of cutaneous and osteocutaneous reconstruction of the head and neck are presented, as well as consecutive series of 36 cases.

MATERIALS AND METHODS

A free scapular flap was used to reconstruct head and neck defects in 36 patients between June 1986 and August 1989. The patients ranged in age from 27 to 83 years, with a mean age of 58 years. The cutaneous scapular flap was used in five cases and the osteocutaneous flap in 31 cases. The latissimus dorsi muscle was transferred with the lateral scapular bone and skin, all based on the same pedicle, in two cases.

All but one of the 36 patients were reconstructed after treatment for head and neck cancer. The primary neoplasm was most often squamous cell carcinoma (27 patients). The one exception was a patient with an extensive orbital-maxillary defect secondary to Wegener's granulomatosis.

The cutaneous scapular flap was used as soft tissue augmentation for two orbital-sinus defects, two scalp defects, and one buccal cavity defect. All five donor sites were closed primarily. The largest donor flap measured 10 × 15 cm.

The osteocutaneous scapular flap was used in 30 cases of mandibular reconstruction and one case involving reconstruction of these maxilla. Primary reconstruction was performed in 55% of cases. Fifteen patients were previously irradiated. Six reconstructions immediately followed resection of osseoradionecrosis of the mandible.

The extent of the mandibular reconstruction is shown

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in Table 1. The length of the vascularized scapula used for reconstruction varied from 8 to 14.5 cm, with a mean length of 10 cm. The scapular bone grafts were sculpted to fit the mandibular defects by strategically located ostectomies. In two patients, 14.5-cm bone grafts replaced mandibular defects from angle to angle. Four osteotomies were required in each case. The majority of the scapular bone grafts were secured in position using direct interosseous wiring and threaded K-wire fixation at the bony junctions. More recently, however, Würzburg titanium miniplates secured by 2.0-mm titanium screws have been used for bony fixation.

In six patients, the cutaneous portion of the osteocutaneous flap was used to replace soft tissue defects of both the oral cavity and external facial skin. In the remaining cases, the cutaneous portion of the flap was used as intraoral lining. Skin paddle size ranged from 3 × 6 cm to 8 × 16 cm. Both scapular and parascapular skin paddles were used in tandem in two patients with large defects requiring oral cavity and external facial skin coverage. In two patients, a portion of the latissimus dorsi muscle was harvested with the osteocutaneous scapular flap to fill defects resulting from extensive resection of the tongue and suprahyoid musculature.

All patients were seen by a physical therapist preoperatively and followed postoperatively. Bilateral shoulder, scapula, and neck range of motion were assessed preoperatively. Shoulder muscle strength using standard isometric manual muscle testing was also recorded using the Oxford scale of 0–5.

Surgical Technique. The free scapular flap is harvested with the patient in the lateral position. The cutaneous flap is designed to meet the soft tissue requirements of the defect. A fairly regular pattern of two major cutaneous branches of the circumflex scapular artery can be followed from the triangular space (Fig 1). The horizontal branch runs over the posterior aspect of the scapula parallel to the scapular spine. A cutaneous paddle designed along this branch is ideal for intraoral coverage or combined intraoral and facial skin defects. A descending cutaneous branch of the circumflex scapula artery runs parallel to the lateral border of the scapula. A parascapular cutaneous paddle based on this descending cutaneous branch is preferred for external facial skin replacement. The scapular and parascapular cutaneous paddles may be harvested simultaneously as a large bilobed cutaneous flap or with the lateral scapular bone as a large bilobed osteocutaneous flap.

The cutaneous paddles are elevated above the deep fascia covering the infraspinatus muscle. In the event that an osteocutaneous flap is desired, dissection proceeds with caution at the lateral border of the scapula, preserving the small branches of the circumflex scapular vessels entering the bone. These small branches are delicately ligated when the purpose is to harvest only the cutaneous portion of the flap. In either case, continued dissection of the vessels proceeds in the muscular triangle (Fig 2). Visualization is improved by dividing the origins of the teres major and minor muscles from the lateral border of the scapula. This maneuver

TABLE 1. Osseous Mandibular Reconstruction

Defect Site	No.
Anterior	8
Lateral	16
Anteriolateral	6

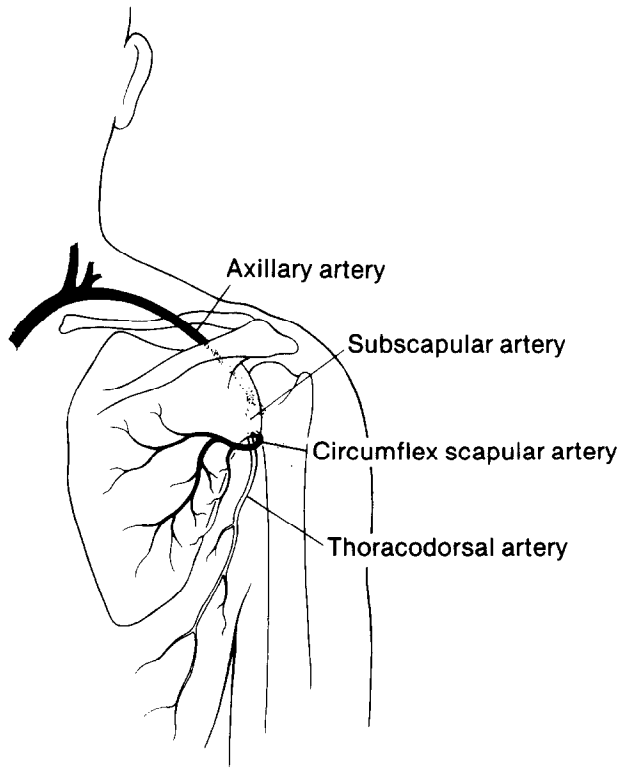

Figure 1. Vascular anatomy of the scapular region. (Reprinted with permission.[8] Copyright 1988, American Medical Association.)

contributes to some of the postoperative shoulder morbidity; therefore, it is not recommended in cases in which bone is not being harvested. The vascular pedicle is followed to the parent axillary artery and vein. Branching vessels should be carefully ligated with vascular clips. The latissimus dorsi myocutaneous flap based on the thoracodorsal vessels can be included with the dissection, in which case the flap is commonly referred to as a "mega flap."

The desired bone length should be carefully measured along the lateral border of the scapula. The overlying infraspinatus muscle is incised down to the periosteum, 3 cm medial to the lateral scapular border (Fig 3). Bone cuts are made using an oscilating saw. The upper transverse bone cut is cautiously made below the glenoid fossa to preserve the joint structures. An angled bone cut at the tip of the scapula can add an additional 1 to 1.5 cm to the bone graft (Fig 4, left).

The donor defect in the case of the osteocutaneous flap is closed by reattaching the teres muscles' origins to the remaining scapula border with nonabsorbable sutures. The sutures are anchored to the drill holes placed in the bone. Occasionally, a portion of the long head of the triceps origin is detached from the lateral border of the scapula in the dissection. The muscle origin is reattached in a similar manner to the remaining bone once the flap has been harvested.

The lateral scapular bone is contoured to the mandibular defect by strategically placed wedge-shaped ostectomies performed with a small reciprocating saw or cutting burr (Fig 4, right). The periosteum is minimally elevated before performing the ostectomies.

Postoperative Care. The shoulder is immobilized for 4 to 5 days following flap harvesting. Gradual shoulder and scapula range of motion exercises are ini-

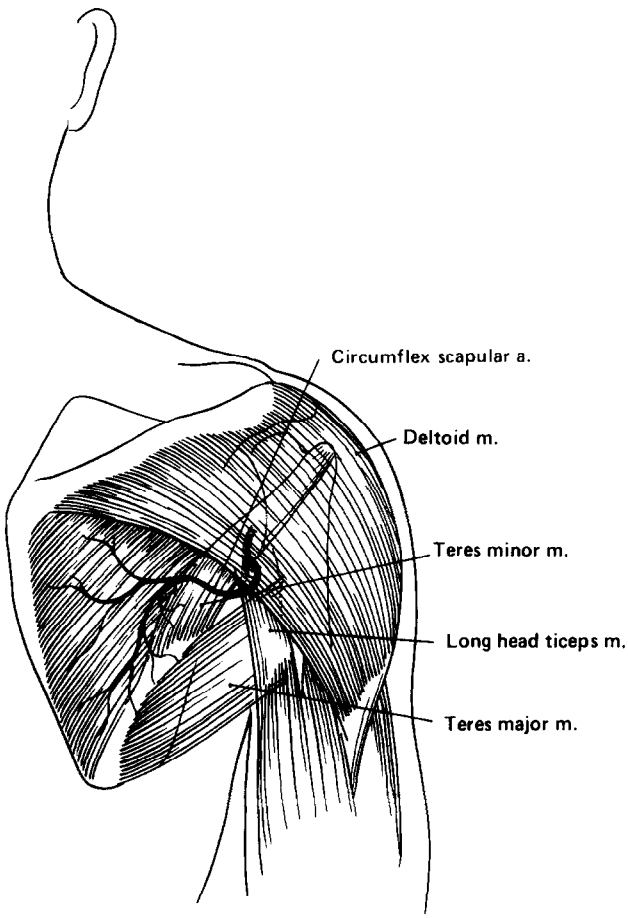

Figure 2. Circumflex scapular vessels identified in the muscular triangle. (Reprinted with permission.[8] Copyright 1988, American Medical Association.)

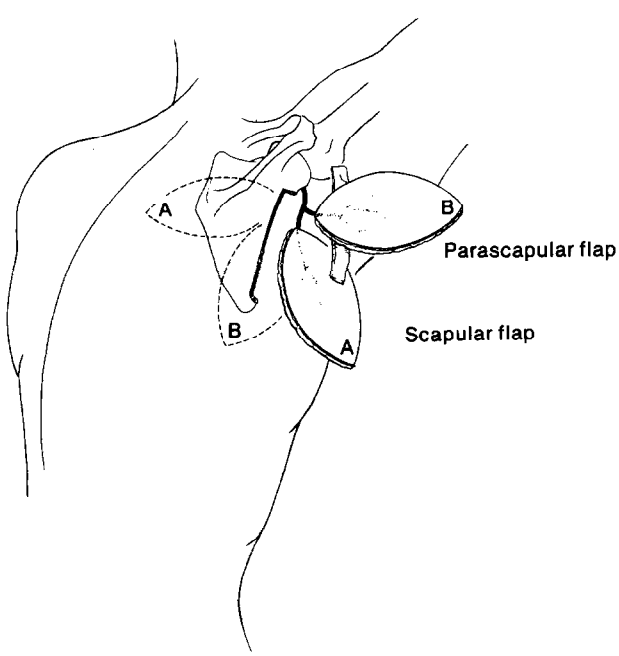

Figure 3. Osteocutaneous scapular flap pedicled by the circumflex scapular vessels. (Reprinted with permission.[8] Copyright 1988, American Medical Association.)

tiated thereafter. A set program of exercises is instituted prior to discharge and is reinforced by home physical therapy and regular office visits. Shoulder and scapular range-of-motion and muscle strength is monitored at regular intervals.

RESULTS

Thirty-three of the 36 patients underwent successful reconstruction with a revascularized scapular flap (cutaneous, 100%; osteocutaneous, 90%) (Table 2). One failure occurred in a patient with osseoradionecrosis of the mandible from angle to angle. This patient developed a large orocutaneous fistula with gross contamination of the neck and vascular pedicle 7 days following primary reconstruction. The cutaneous portion of the flap was clinically viable and a pulse was detected by Doppler ultrasound prior to the seventh postoperative day. A bone scan showed uptake of tracer activity along the entire length of the bone graft on day 5, suggesting vascular patency. Bone scan reexamination on day 7 revealed circulatory collapse to the graft. Reexploration confirmed gross contamination of the pedicle with thrombosis. Several attempts failed to reestablish adequate circulation.

A second flap failed as a result of arterial insufficiency. This patient had been previously heavily irradiated and, on reexploration, the recipient artery was found to be kinked and thrombosed. An attempt at revascularization resulted in unmitigated venous congestion. Venous thrombosis was the cause for the loss of a third flap on the fifth postoperative day. Flap rescue was also unsuccessful at reexploration.

One patient died of pancreatitis on the 12th postoperative day. This patient developed epidermolysis of the cutaneous surface of the flap; however, the remaining portions of the flap were viable prior to the patient's demise. A bone scan obtained on the fifth postoperative day revealed intense tracer activity along the bone graft. The patient's family refused necropsy.

All but two patients had solid bony unions. Bone healing was assessed clinically and radiologically at each junction between the bone graft and the remaining mandible. One patient lost the distal 3 cm of a 14.5-cm bone graft due to an overaggressive ostectomy. Bone scan confirmed the nonviable portion of the graft. This sequestrum of bone was debrided while the remaining portion of the osteocutaneous flap remained viable. The patient refused further treatment as the bone healed by an asymptomatic fibrous union. In a second patient, a single titanium miniplate failed to secure the bony junction. With the patient on a soft diet, this union also healed by an asymptomatic

Figure 4. Bone contouring to fit the defect by (left) including the scapular spine to simulate the mandibular ramus or (right) strategically placed ostectomies.

fibrous union. As a consequence of this experience, we are currently using the intermediate-size plates for fixation.

There were no complications in the group of five patients who underwent cutaneous scapular flap reconstruction. All of these patients regained full shoulder function and range of motion. The two flaps used for orbital-sinus reconstruction required debulking for improved cosmesis.

Minor surgical complications occurred in 28% of the scapular flap patients (Table 3). Two patients developed minor orocutaneous fistulas postoperatively that closed spontaneously. Both patients were reconstructed primarily following mandibular resection for osteoradionecrosis. An infection of the donor site occurred in three cases. In one patient, a second surgical procedure was required prior to healing. The other two infections resolved with oral antibiotics. One other patient developed a minor wound infection and dehiscence of the lip-splitting incision, which was debrided surgically and closed primarily.

Complete preoperative and postoperative physical therapy was available for 66% of all patients. All patients experienced decreased scapulohumeral function as a result of harvesting the scapular osteocutaneous flap. Shoulder strength and range of motion with respect to flexion, abduction, and external rotation were primarily affected. Half of these patients showed mild to moderate limitation of scapular abduction and external rotation at 6 months. Five patients demonstrated a slight decrease in shoulder flexion at that time. In several of the osteocutaneous scapular flap cases, the spinal accessory nerve was sacrificed with cancer resection, significantly contributing to the patient's disability. All patients considered their shoulder motion functionally adequate 6 months postoperatively.

DISCUSSION

Large head and neck defects, whether a result of cancer ablation, trauma, or infection, continue to challenge the reconstructive surgeon. Although pedicled osseomusculocutaneous and musculocutaneous flaps do permit immediate reconstruction in the head and neck region, they are limited by the length of their vascular pedicle and the tenuous vascularity of the transferred bone.[10] Freed from the restraint of the vascular pedicle, free tissue transfer has greatly expanded our armamentarium for the reconstruction of head and neck defects and expanded the opportunity for more esthetic and functional reconstruction. Scapular cutaneous and osteocutaneous flaps have distinct advantages for head and neck reconstruction. The scapular flap has a very predictable

TABLE 2. Revascularized Scapular Flap

Major Complication (14%)	No.
Flap necrosis	3
Fistula	1
Partial bone loss	1
Death	1

TABLE 3. Revascularized Scapular Flap

Minor Complication (28%)	No.
Superficial flap epidermolysis	1
Fistula	2
Hematoma	1
Seroma	1
Wound infection	4
Fixation plate failure	1

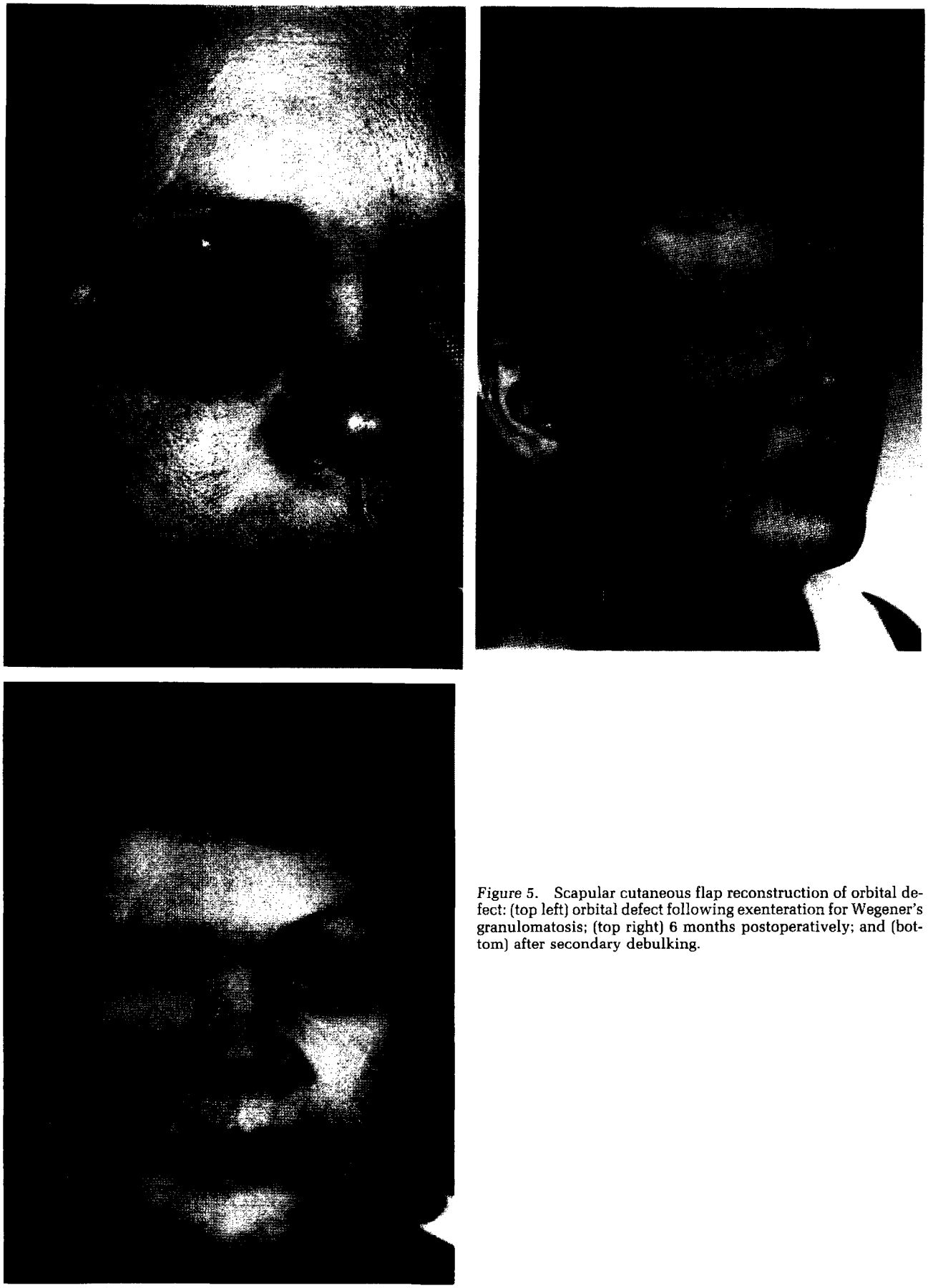

Figure 5. Scapular cutaneous flap reconstruction of orbital defect: (top left) orbital defect following exenteration for Wegener's granulomatosis; (top right) 6 months postoperatively; and (bottom) after secondary debulking.

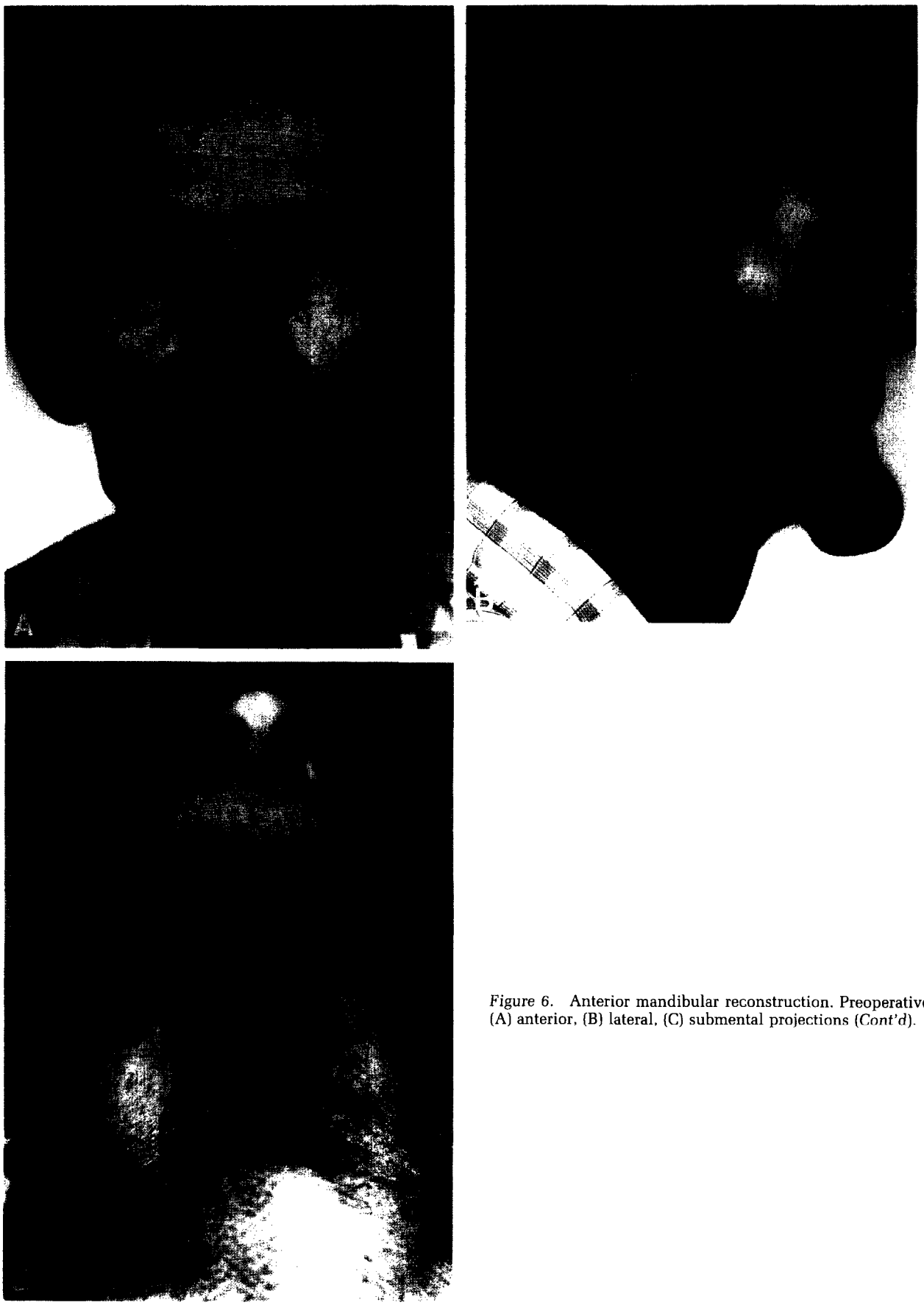

Figure 6. Anterior mandibular reconstruction. Preoperative: (A) anterior, (B) lateral, (C) submental projections (*Cont'd*).

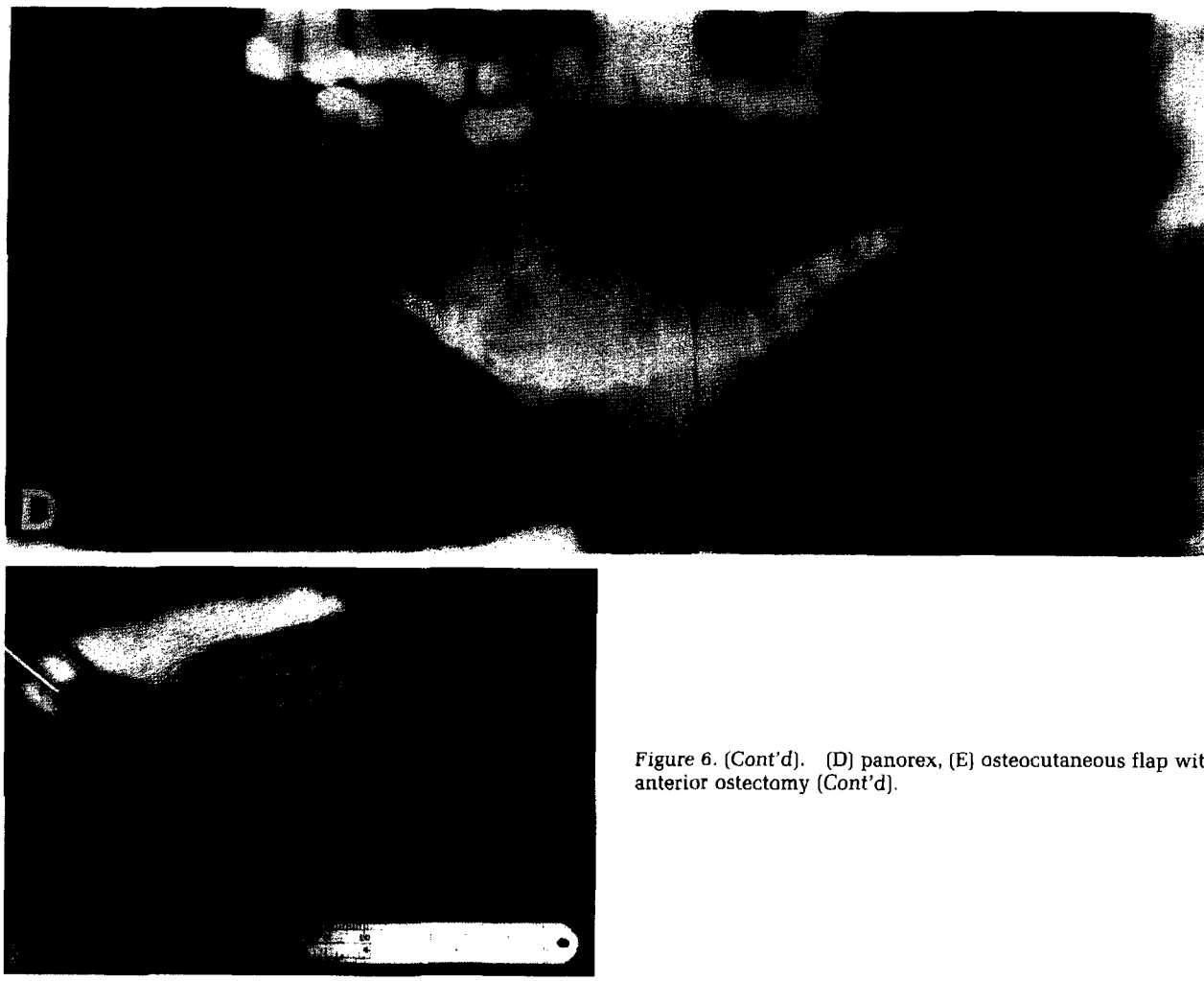

Figure 6. (*Cont'd*). (D) panorex, (E) osteocutaneous flap with anterior ostectomy (*Cont'd*).

vascular anatomy that facilitates its dissection. Both the cutaneous flap and the osseocutaneous flap are easily harvested in approximately 1 to 1.5 hours, respectively. With the patient in the lateral decubitus position, the scapular flap can be harvested as a separate team works in the head and neck region. The dissection, however, may be tedious in overweight patients who have a more subcutaneous tissue. This situation may prevent simultaneous flap harvesting and recipient site preparation.

The subscapular vessels are "macrovascular" in size, with an average diameter of 2.5 to 4.0 mm, and are an excellent match for most recipient vessels in the neck. A generous pedicle length of 7 to 10 cm facilitates reconstruction of soft tissue and bony defects with the vessel anastomosis in the neck. The flap does not have an accompanying sensory nerve, which may be a disadvantage if sensate skin is desired.

We have found the scapular cutaneous flap an especially versatile soft tissue flap adaptable to the reconstruction of a variety of head and neck defects. The bulkiness of this flap is dependent on the thickness of the back skin and subcutaneous tissue. It can be rather bulky in some individuals. The flap is intermediate in thickness between the thin radial forearm flap and the bulky latissimus dorsi myocutaneous flap. The subcutaneous fat of the scapular cutaneous free flap can be advantageous in situations requiring more soft tissue augmentation. For head and neck defects requiring smaller amounts of thin tissue, such as in the face, the cutaneous scapular flap may require secondary debulking and liposuction (Fig 5). The radial forearm flap may actually be preferable in these situations. Finally, a large volume of tissue can be harvested with essentially no donor site morbidity.

The free osseocutaneous scapular flap has proven to be ideal for mandibular reconstruction (Fig 6). The lateral border of the scapula provides an excellent source of highly vascularized corticocancellous bone. Ten centimeters of bone can usually be transferred with the flap in petite women, and 14 cm in men. An additional 3 to 4 cm of length can be obtained by including an angulated portion of the scapular tip. We were able to reconstruct angle to angle defects in two male patients with 14.5 cm of bone. Typically, however, the

Figure 6. (Cont'd). Postoperative: (F) anterior, (G) lateral projections, (H) panorex. (Reprinted with permission.[9])

scapular flap will not provide enough bone for defects greater than 14 cm in size.

Large cutaneous paddles can be transferred with the osseocutaneous flap, particularly when both cutaneous branches of the circumflex scapular artery are included. The cutaneous portion of the flap has a rich subcutaneous vascular network; therefore, it can be incised and the flap folded on itself for combined external and internal oral defects. All, or a portion of, the skin can be deepithelialized for deep tissue augmentation. Typically, a small strip of skin is retained with the flap as an indicator of viability.

An additional 2 to 3 cm of vascular pedicle separates the skin flap from the scapular bone. The three-dimensional maneuverability of the skin

flap relative to the bone significantly facilitates soft tissue reconstruction (Fig 6E). In comparison, the skin of the free compound groin flap must remain intimately associated with the bone and muscle of the iliac crest because of the direct myocutaneous perforating vessels. In our experience, this often limits the reconstructive options with regard to flap positioning and adds excessive bulk to the reconstruction.

The maleable scapular bone is easily sculpted to replace both lateral and anterior mandibular defects. In all of our cases, major deformity would have resulted without mandibular reconstruction. Contouring the bone graft is relatively easy with strategically placed ostectomies. The primary blood supply to the bone is transported through the periosteum; therefore, it is important that the periosteum is minimally stripped in creating the ostectomies. The ostectomy sites are reliably secured with titanium miniplates.

Five patients in this study have been fitted with tissue-borne denture prostheses. The scapular bone also appears adequate to allow the placement of osseointegrated implants that can serve as tooth root analogs (Fig 7). None of the patients in this series had implants placed primarily at the time of reconstruction, although several are in various stages of dental rehabilitation with osseointegrated implants.

The scapular osseocutaneous flap has some limitations. Its disadvantages are the shoulder disability experienced by some patients, and the limited 14-cm length of bone that can be harvested in the adult. The iliac crest osseomyocutaneous flap is a preferred source of bone for defects exceeding 14 cm. However, we have found the iliac crest bone more difficult to conform to anterior mandibular defects, and the bulky nature of the soft tissue makes it difficult to recreate chin and submental definition in cases requiring external coverage.

Preoperative and postoperative physical therapy is essential in limiting the patient's functional morbidity. Although all patients in this survey considered their shoulder motion functionally adequate 6 months postoperatively, half had mild to

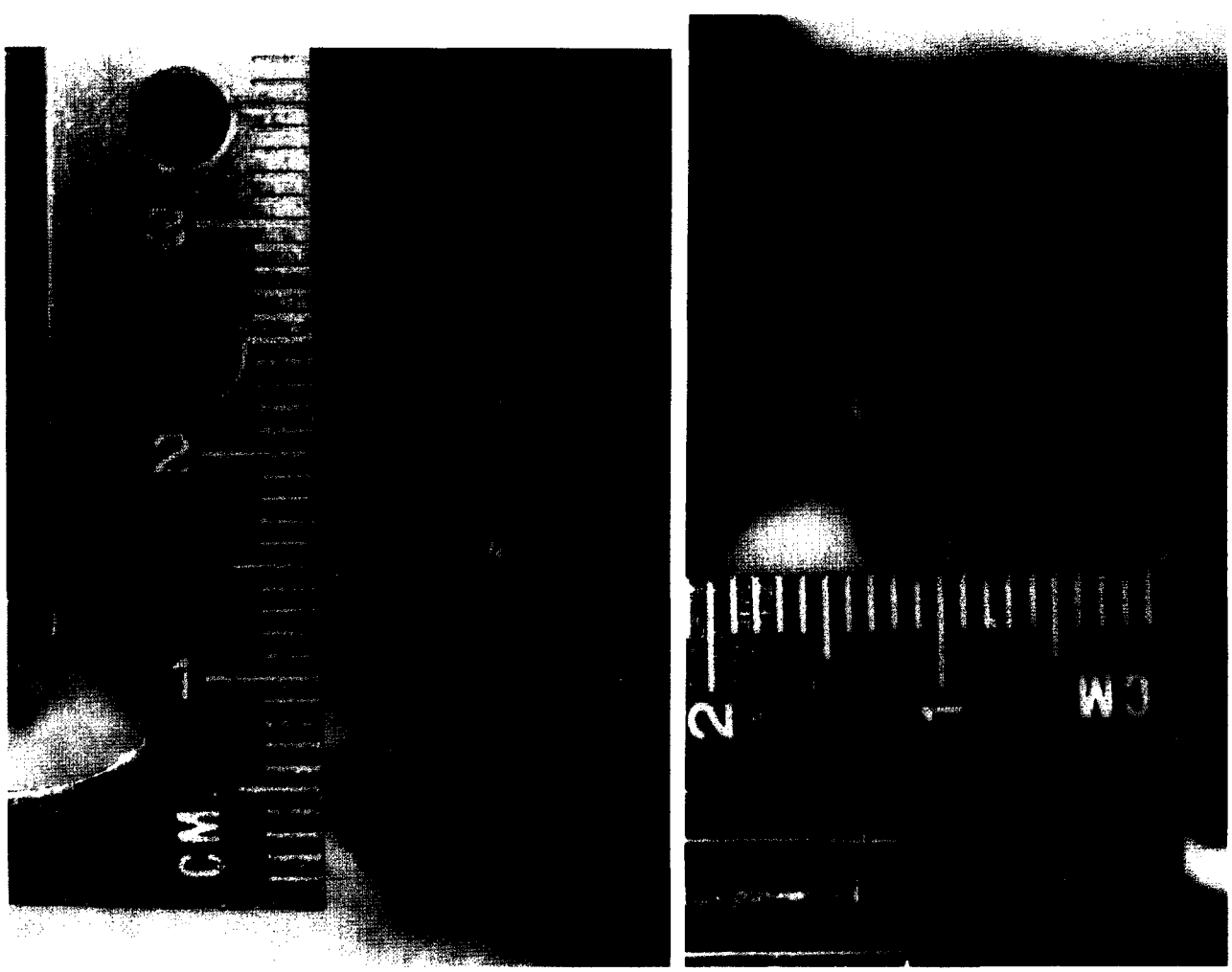

Figure 7. Transverse section of typical scapular bone graft: (left) vertical height of 2.5 cm, and (right) width of 1.0 cm.

moderate limitations of shoulder abduction and external rotation at that time. Many other factors play a role in shoulder rehabilitation, including the patient's attitude and willingness to participate in postoperative physical therapy, nutrition, spinal accessory nerve function, and radiation therapy.

CONCLUSION

The free scapular flap is a reliable, highly vascularized flap that is ideal for the reconstruction of soft tissue defects as well as large composite defects of the head and neck. Our satisfaction with this flap is due to the independent arc of skin flap rotation relative to the bone and the ease of contouring the bone flap, as well as the ease of harvesting and minimal donor site morbidity.

References

1. Maisel RH, Hilger PA, Adams GL: Reconstruction of the mandible. Laryngoscope 1983; 93:1122-1129
2. DeFries HO, Marble HS, Sell KW: Reconstruction of the mandible. Arch Otolaryngol 1971; 93:426-431
3. Daniel RK, Taylor GI: Distant transfer of an island flap by microvascular anastomosis. Plast Reconstr Surg 1973; 52:111
4. Saijo M: The vascular territories of the dorsal trunk: A reappraisal for potential flap donor sites. Br J Plast Surg 1978; 31:200-205
5. dos Santos LF: Retalmo circulare: Un novo retalmo livre microcirurgico. Rev Bras Cir 1980; 70:133-137
6. Teot L, Bosse JP, Moufarrege R, et al: The scapular crest pedicled bone graft. Int J Microsurg 1981; 3:257-262
7. Swartz WM, Banis JC, Newton ED, et al: The osteocutaneous scapular flap for mandibular and maxillary reconstruction. Plast Reconstr Surg 1986; 77:530-545
8. Baker SR, Sullivan MJ: Osteocutaneous free scapular flap for one-stage mandibular reconstruction. Arch Otolaryngol 1988; 114:267-277
9. Sullivan MJ, Baker SR, Crompton R, et al: Free scapular osteocutaneous flap for mandibular reconstruction. Arch Otolaryngol 1989; 115:1334-1340
10. Ariyan S: Further experiences with the pectoralis major myocutaneous flaps for immediate repair of defects from excisions of head and neck cancers. Plast Reconstr Surg 1979; 64:605-612