

Table 1. Patient Characteristics and Operative Results

Patient	Age (y)	Type of Reconstruction	Radiation History	Estimated, Required Tissue Volume (ml)	Estimated Total Flap Volume (ml)	Type of Flap	Final TE Volume (ml)	Final Flap Weight (g)	Total Flap Weight (g)	Complications	Cosmetic Results	Volume Difference (ml)*
1	58	Immediate	No	487	1088	Single pedicle	NA	526	999	No	Good	+43
2	53	Immediate	No	394	442	Double pedicle	NA	350	455	No	Excellent	+1
3	46	Immediate	No	789	1340	Single pedicle	NA	886	1583	Yes (partial necrosis)	Good	+64
4	50	Immediate	No	889	972	Double pedicle	NA	816	875	No	Excellent	+36
5	46	Delayed-immediate	No	531	592	Double pedicle	500	538	655	No	Excellent	-28
6	56	2-Stage, delayed	No	197	510	Single pedicle	300	228	467	No	Excellent	+20
7	50	2-Stage, delayed	Yes	632	1596	Single pedicle	800	747	1512	No	Fair	-86
8	63	2-Stage, delayed	No	778	1330	Double pedicle	850	866	1285	No	Good	-48
9	44	2-Stage, delayed	Yes	188	346	Single pedicle	250	175	336	No	Excellent	-5
10	51	2-Stage, delayed	No	463	604	Double pedicle	475	508	542	No	Excellent	+19
11	41	2-Stage, delayed	No	432	608	Double pedicle	525	438	550	No	Excellent	+28

\*Postoperative volume difference was calculated as the reconstructed breast volume minus the contralateral breast volume. NA, not applicable; TE, tissue expander.

Industries, Brooklyn, N.Y.), and the mold was sterilized with ethylene oxide gas for intraoperative use (Fig. 1D).

After flap elevation, total flap weight was measured and the excess portion trimmed according to the estimated required flap volume. For convenience, volume (ml) was considered equal to weight (g).<sup>10</sup> With the double-pedicle flap, intraflap pedicle-to-pedicle anastomosis was also performed. When vascular anastomosis and de-epithelialization were completed, the flap was carefully placed into the mold (Fig. 1E). After determination of optimal positioning and additional trimming, the flap was fixed and shaped with absorbable sutures from the bottom.

### Postoperative Evaluation

Cosmetic outcomes were evaluated on a 4-point visual analogue scale as previously described.<sup>11</sup> Two health professionals assessed cosmetic outcomes as excellent, good, fair, or poor. 3D measurements of bilateral breasts were performed at 2 months postoperatively, and volume difference between the reconstructed and contralateral sides was assessed.

We state that all procedures conformed to the Declaration of Helsinki, and appropriate informed consent was obtained from the patients.

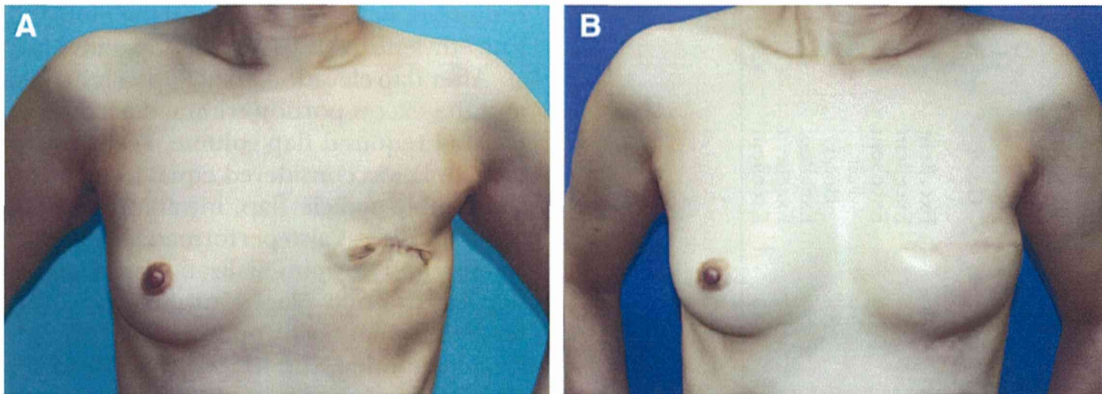
## RESULTS

Patient characteristics and outcomes are shown in Table 1. Five flaps were single-pedicle and 6 were double-pedicle. Correlation between estimated total flap volume (ml) and actual total flap weight (g) was excellent ( $r^2 = 0.95$ ;  $m = 0.99$ ). The value of final flap weight tended to be slightly larger than the value of estimated required flap volume in anticipation of postoperative shrinkage.<sup>12,13</sup>

There was no flap loss or other major complication during the follow-up period, except for partial fat necrosis in 1 single-pedicle flap. Cosmetic outcomes were satisfactory (excellent, 7 cases; good, 3 cases; and fair, 1 case), as confirmed by the postoperative 3D measurements of the volume difference between the reconstructed and contralateral sides (mean volume difference, 34.4 ml; range, 1–86 ml). Sufficient volume replacement with DIEP flap resulted in good breast projection and symmetry for most cases (Figs. 2, 3).

## DISCUSSION

Reconstructed breast shape is mainly affected by neoparenchyma and skin envelope.<sup>14</sup> Although DIEP flaps offer a sufficient amount of tissue as neoparenchyma, determining the optimal amount requires skill and experience. We believe 3D surface imaging offers stable estimates of required tissue volume, as evidenced by satisfactory cosmetic outcomes



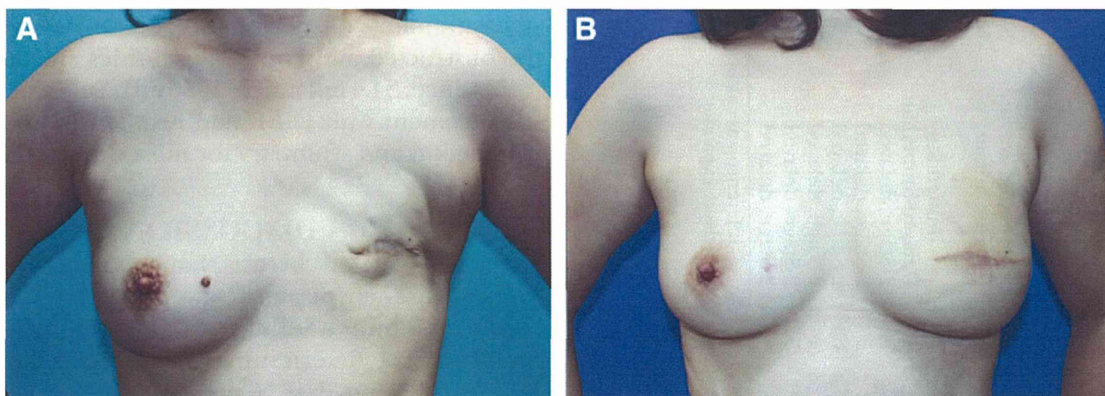
**Fig. 2.** A 56-year-old woman (patient 6) underwent total mastectomy of the left breast. One year later, she underwent 2-stage delayed reconstruction with a DIEP flap. The preoperative (A) and 4-month postoperative (B) views are shown.

and postoperative 3D measurements. 3D surface imaging also aids in surgery planning, especially when a large volume of tissue is required to reconstruct a symmetrical breast. Without the estimation of total flap volume and required tissue volume, flap type (single- or double-pedicle) is merely subjectively determined using fluorescent perfusion techniques. In such situations, underestimation of required tissue volume would result in insufficient breast volume, especially in a single-pedicle flap. A preoperative decision on flap type based on the objective data can make surgery more circumspect and accurate.

Shaping flat adipocutaneous tissue into a 3D structure can be challenging,<sup>15</sup> especially in cases where a high-profile breast must be shaped from an entire, thin DIEP flap (eg, patients 4, 5, 10, and 11). We found the 3D-printed breast mold to be a simple, quick, and inexpensive solution. Owing to its flexible nature, the de-epithelialized DIEP flap placed in a breast mold automatically changes into a shape symmetrical to the contralateral breast and only needs minor adjustments. Material costs were less than 5 dollars per mold.

There are potential drawbacks to this method. Because 3D surface imaging does not take skin envelope thickness into account, and chest wall shape is estimated by 3D analysis software, there could be errors between the estimated and real tissue volume required. In immediate reconstruction, however, the errors can be corrected by intraoperative measurement of real tissue volume (or weight) resected. We found the errors to be within an allowable range for preoperative determination of flap type. Because the previously mentioned errors are offset during calculation of the breast volume difference between both sides, estimation of required tissue volume in delayed reconstruction was more accurate than in immediate reconstruction.

Because our breast mold is created based on the 3D surface imaging, and a DIEP flap is inserted into the subcutaneous pocket, the reconstructed breast is likely to be slightly larger than the contralateral breast (due to skin envelope thickness). We consider it convenient for obtaining a symmetric breast because some postoperative reduction usually occurs (5–10%) as swelling disappears.<sup>12,13</sup> However, when



**Fig. 3.** A 41-year-old woman (patient 11) underwent total mastectomy of the left breast. Three years later, she underwent 2-stage delayed reconstruction with a DIEP flap. The preoperative (A) and 3-month postoperative (B) views are shown.

the breast skin is reconstructed with a flap, it would be difficult to oversize the reconstructed breast in a balanced manner.<sup>16</sup>

### CONCLUSIONS

In conclusion, the 3D imaging technologies allow for digital quantification of complex breast tissue and circumspect preoperative planning. We believe that DIEP flap reconstruction assisted with 3D surface imaging and a 3D-printed mold is a simple and quick method to rebuild a symmetric breast even for less experienced surgeons.

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# Eyebrow Reconstruction Using a Composite Skin Graft from Sideburns

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**Summary:** Wide resection of malignant skin tumors in the upper orbital region often results in soft-tissue defects involving the eyebrow. We used composite skin grafts from the area around the sideburns for 1-stage reconstruction of skin and eyebrow defects. The results were aesthetically satisfying because the hair and shape of these regions were similar to those of the original eyebrow, and donor-site closure was easy with inconspicuous scar. The survival of full-thickness skin graft area of composite grafts from sideburn facilitates revascularization of thicker hair follicles in the graft and allows safe, natural eyebrow reconstruction. (*Plast Reconstr Surg Glob Open* 2015;3:e290; doi: 10.1097/GOX.0000000000000264; Published online 13 January 2015).

**R**econstruction of soft-tissue defects involving the eyebrow requires careful attention to achieve cosmetically satisfactory results. We used composite skin grafts harvested from sideburns for simultaneous reconstruction of the eyebrow and an associated skin defect. Grafts from sideburn areas can convey intermediate hair, which is suitable for eyebrow reconstruction. In addition, the grafts can include preauricular and/or cheek skin, the color and texture of which is a good match for reconstructing the eyebrow region. The angle between hair shafts and skin is sharp in sideburns and closely simulates that of the eyebrow.

## SURGICAL PROCEDURES

The eyebrow and associated skin defect are partially closed to minimize graft size. This is done with great care, to avoid leaving a significant deformity

in the forehead and upper eyelid. The graft is then carefully designed at the donor site (Fig. 1). Graft design relies on 2 principles. First, in eyebrows, the direction of follicles is typically superolateral in the medial and inferior regions and inferolateral in the lateral and superior regions.<sup>1</sup> By contrast, hair stream is predominantly in the inferior direction in sideburns. After noting the characteristics of hair stream, the graft is harvested. The other principle is assessment of skin thickness. The suprabrow and infrow regions substantially differ in dermis thickness. In addition, preauricular skin is thin, but cheek skin is thick. Graft thickness must be adjusted to match that of the defect. When hair stream and skin thickness are considered, a graft from the contralateral side seems most suitable. However, the donor site should be located as posteriorly as possible. If mainly preauricular skin is harvested, cheek skin can be preserved and the donor-site scar will be inconspicuous. Thus, we prefer to harvest grafts from the contralateral side for reconstructing defects that mainly involve the infrow area and grafts from the ipsilateral side for suprabrow defects. After graft harvesting, the subcutaneous fat of the non-hair-bearing area is removed, after which the galea and subcutaneous tissue are removed in the hair-bearing

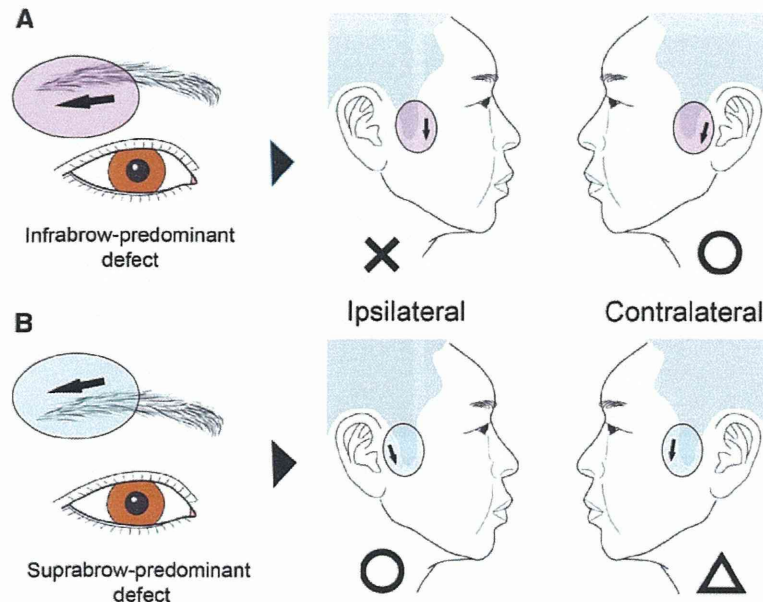
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**Fig. 1.** After matching the hair stream (black arrow), the side of the graft harvest (ipsilateral vs contralateral) is determined by examining the location of the defect. A, The contralateral side is preferred for infrabrow-predominant defects, as the hair stream and skin thickness are matched and the donor-site scar is inconspicuous. B, Because of considerations related to hair stream and donor-site scar visibility, the ipsilateral side is usually selected for suprabrow-predominant defects even though skin thickness typically differs at the defect and donor sites.

area, which keeps hair follicles intact. The donor site of the graft is then primarily closed.

### CASE REPORT

#### Case 1

A 64-year-old woman with basal cell carcinoma involving the right eyebrow underwent wide resection, resulting in a 22×19mm defect at the lateral one third of the eyebrow. The lateral area of the defect was partly closed, and a composite skin graft was harvested from the ipsilateral side. The postoperative course was uneventful, and the graft survived completely. Fifteen months after surgery, the graft is well matched to the defect, with aesthetically satisfying results (Fig. 2).

#### Case 2

An 82-year-old woman with a squamous cell carcinoma involving the right eyebrow area underwent wide resection, resulting in a 47×40mm defect at the lateral half of the eyebrow. The lateral area of the defect was partly closed, and a composite skin graft was harvested from the ipsilateral sideburn. The donor site was primarily closed. Her postoperative course was uneventful, and the graft survived completely. Eighteen months after surgery, the graft

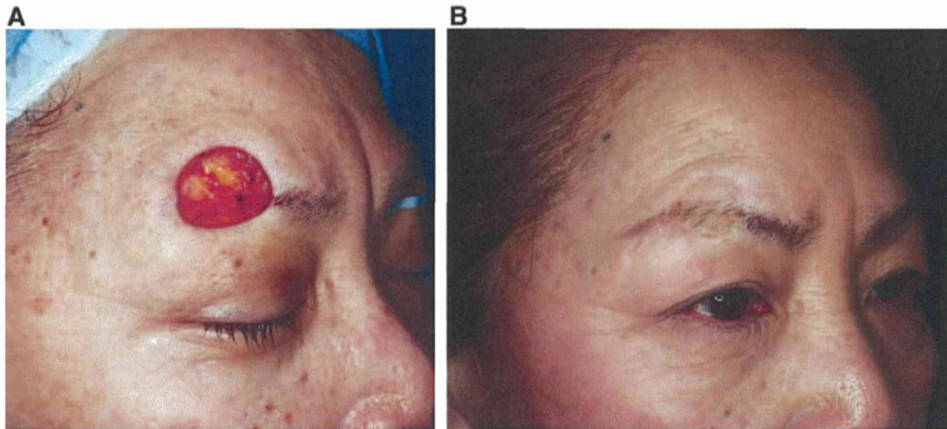
is well matched to the defect and has an eyebrow-like appearance (Fig. 3).

This method was used in another case. (See **Figure, Supplemental Digital Content 1**, which displays an 86-year-old woman with squamous cell carcinoma involving the left eyebrow who underwent wide resection, resulting in a 45×35mm defect at the lateral two thirds of the eyebrow (left), <http://links.lww.com/PRSGO/A82>.)

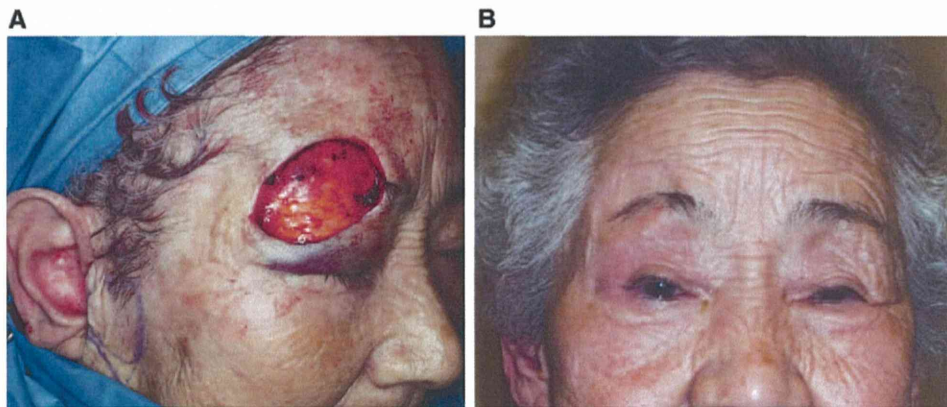
### DISCUSSION

Methods of eyebrow reconstruction include local flaps, pedicled flaps, and hair transplantation. For relatively small defects, local flaps including the remaining eyebrow<sup>2,3</sup> can yield good results; however, large defects require a scalp flap or secondary hair follicle graft. Because eyebrow hair is short and of a small diameter, use of pedicled scalp flaps<sup>4</sup> can result in a “brush-like” appearance, as the hair is much denser and thicker than that of the original eyebrow. Although this might be acceptable for men, it is not suitable for women<sup>5</sup>; however, the use of intermediate hair<sup>6</sup> or postoperative laser treatment<sup>7</sup> might address this problem.

The use of a free composite graft from the scalp might be a good option for transferring a substan-



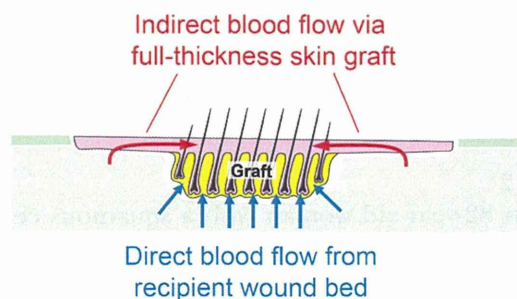
**Fig. 2.** A, An intraoperative photograph showing a 22 × 19 mm defect at the lateral one third of the eyebrow. The lateral area of the defect was partly closed, and a composite skin graft was harvested from the ipsilateral side. B, Fifteen months after surgery, the graft is well matched to the defect, with aesthetically satisfying results.



**Fig. 3.** A, An intraoperative photograph showing a 47 × 40 mm defect involving the lateral half of the eyebrow. This suprabrow-predominant defect was treated using an ipsilateral graft. B, A photograph at 18 months postoperatively. The graft matches well with the defect. Sideburn hair gives the reconstructed eyebrow a natural appearance.

tial number of hair follicles in a 1-stage operation. However, because the success of this procedure depends on the vascularity of the recipient site, it is not suitable for all patients. Follicular hair transplantation is more reliable and maintains a natural appearance in the reconstructed eyebrow<sup>8</sup>; however, this procedure requires multiple stages.

Composite skin grafting is itself not a new technique. It was already being used in the 1960s<sup>9</sup> for reconstructing eyebrow and upper eyelid defects. The advantage of composite skin grafting is that it reestablishes the numerous vascular connections between the rete arteriosum cutaneum and the anterior plexus around the hair follicles. The taking



**Fig. 4.** Schematic illustration of a composite skin graft. The scalp graft area is vascularized both by direct blood flow from the recipient bed (blue arrows) and indirect blood flow from the full-thickness graft area (red arrows). This combined vascular network enhances blood flow, which increases survival of transplanted hair follicles.

of a full-thickness skin graft area leads to increased graft vascularity, which increases the survival of transplanted hair follicles (Fig. 4). We used grafts comprising sideburn hair with preauricular and cheek skin instead of nape hair with retroauricular skin.<sup>9</sup> The thinness of the hair, the sharp angle between the hair shafts, and the skin in sideburns closely mimic the characteristics of the original eyebrow. The grafts harvested from sideburns are suitable to reconstruct the multiple natural hairline borders because sideburns contain anterior, posterior, and inferior hairline borders within a narrow area, which is quite useful for reconstructing the natural inferior, superior, and lateral borders of the eyebrow. Because composite skin grafting has cosmetic disadvantage to local flaps including the remaining eyebrow, it should be indicated for larger defects for which the local flaps are difficult to be used, especially including the lateral border of the eyebrow.

Our technique is mainly for patients with malignant skin neoplasms, most patients are relatively old. Preauricular skin is looser during old age, which simplifies primary closure of the donor site.

Our results indicate that composite skin grafting from the sideburn area is a useful option for 1-stage reconstruction of large skin defects involving the eyebrow.

### CONCLUSIONS

Composite skin grafting from the sideburn area yielded satisfactory results in natural eyebrow reconstruction and allowed easy donor-site closure. The take of full-thickness skin grafts enhanced survival of hair follicles, which enabled safe eyebrow reconstruction.

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### PATIENT CONSENT

*Patients provided written consent for the use of their image.*

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## LETTER TO THE EDITOR

### Simple Method to Prevent Retention of Skin Staples

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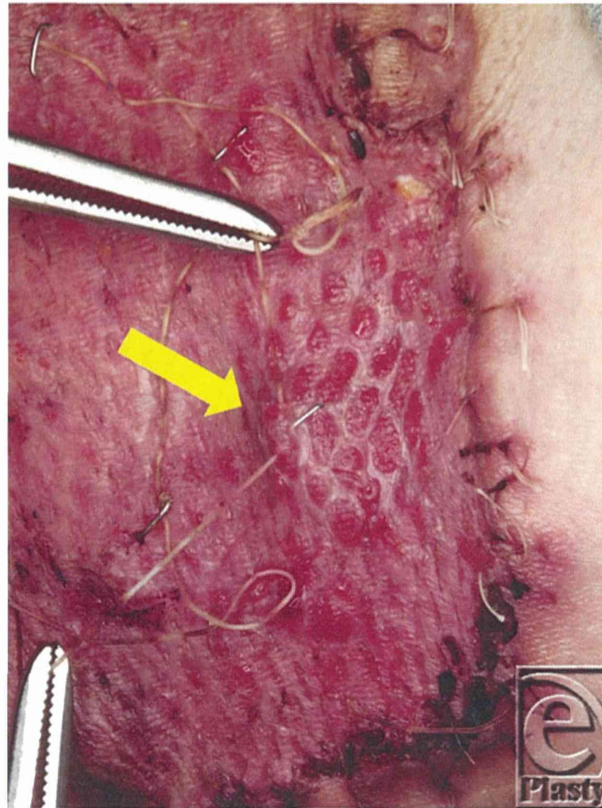
Dear Sir,

Skin stapling devices are widely used to secure skin graft because they are easy to use and useful—especially for large grafting areas. They can save operating time and improve graft taking.<sup>1</sup> However, if not removed at the appropriate time, stainless steel staples are easily buried in overgrown granulation tissue or epithelium, after which they are sometimes difficult to retrieve. Although buried staples do not generally result in adverse effects, they can provoke symptoms<sup>2</sup> and result in medicolegal difficulties, as they are easily noticed in radiographs<sup>3</sup> during long-term follow-up. Biodegradable skin staples have been developed to address these concerns<sup>4</sup>; however, the cost and inelasticity of these staples limit their utility.<sup>5</sup> Although solutions for dealing with retained metal staples have been reported,<sup>3,5</sup> prevention is clearly the better alternative. Skin stapling over a nonadhesive dressing material can prevent growth of tissue over staples but may result in difficulties with changing dressings and graft inspection.<sup>3</sup> To prevent unintentional retention of staples, we staple skin grafts with 2-0 or 1-0 silk thread (Fig 1). These stapled silk threads do not interfere with postoperative dressing change or graft inspection. All staples are removed by lifting the silk thread at 1 week postoperatively (Fig 2). This method was successfully used for seven patients who underwent mesh skin grafting; no staples were retained. This simple and inexpensive method avoids the physical and medicolegal problems associated with staple retention.





**Figure 1.** The meshed skin graft was stapled with 2-0 or 1-0 silk thread. The ends of the silk threads were tied together to avoid accidental removal.



**Figure 2.** On postoperative day 7, all staples were removed by lifting the silk threads. Even on postoperative day 7, some staples were going to be buried in granulation tissue (arrow) but were easily detected because of the silk thread stapled to them.

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