The ischial region is the site most affected by pressure sores, with the highest recurrence and complication rates among common affected sites.1,2 Following recurrence, another donor site is needed for an additional reconstructive procedure. Workhorse flaps for ischial pressure sores have included inferior gluteus maximus island,3 gluteal thigh,4 V-Y hamstring musculocutaneous,5 and gracilis musculocutaneous flaps.6 Each flap has advantages and disadvantages, such as the distance between the ischial bone and the vascular pedicle of the flap, flap volume, and flap tension when in the sitting position. 

Perforator flaps are a safe and dependable method used in reconstructive plastic surgery.7,8 The con-
cept of a freestyle perforator flap, in which a flap is harvested based only on preoperative Doppler signal mapping, was introduced by Wei and Mardini in 2004. Since then, freestyle pedicle perforator flaps based on different pedicles of the body have been proposed, and their clinical usefulness and safety have been demonstrated. Freestyle pedicle flaps based on an internal pudendal artery perforator (iPap) have been reported for perineal and buttock reconstruction. These flaps have included the iPap gluteal-fold flap, iPap V-Y flap, and iPap transposition or propeller flap. In the present report, a new freestyle pedicle flap, the iPap thigh flap, which is based on a skin perforator of the internal pudendal artery and is elevated from the thigh region for transplantation to an ischial defect such as a pressure sore, is presented. The aim of this study was to evaluate the possibility of using this flap through anatomical and theoretical analyses and a case series using computed tomography angiography.

**MATERIALS AND METHODS**

**Anatomical Analysis of the Flap Pedicle**

Details about the distribution of the internal pudendal artery and its skin perforators in the perineal region in the lithotomy position have been described in previous reports. In this study, the focus was on the relationships among the ischial tuberosity, internal pudendal artery, and its skin perforators. The internal pudendal artery branches off from the internal iliac artery in the pelvis, runs inside the sacrotuberous ligament, and emerges into the ischiorectal fossa as the perineal artery that distributes to the anterior portion of the perineal region. Skin perforators can be found in thick fatty tissue of the ischiorectal fossa, which is identified by a triangle (vascular triangle) formed by 3 points, the ischial tuberosity, the anus, and the vaginal orifice or scrotum. The internal pudendal artery is protected by the sacrotuberous ligament, and skin perforators are preserved in thick fatty tissue in the ischiorectal fossa (Fig. 1).

**Patients**

Five patients who had ischial lesions and arterial sounds heard in the “vascular triangle” were selected for iPap thigh flap transplantation in Tokushima University Hospital and Kochi Health Sciences Center from March 2009 to September 2013. Four patients had ischial pressure sores, and 1 had calcinosis cutis in the ischial region (Table 1). Of 5 patients, 3 patients had a history of surgery for their ischial pressure sores.

One patient (case 1) underwent computed tomography angiography with fistulography of his pressure sore to observe the damage to or effects on the pedicle vessels of the flap. Angiography was performed because of hard scar tissue in the vascular triangle and around the ischial region and a deep, wide ischial pressure sore extending to the ischial tuberosity (Fig. 3).

**Flap Design and Elevation**

Arterial sounds were identified and marked with a hand-held Doppler probe in the vascular triangle in the lithotomy position (Fig. 3), with the long-axis line of the thigh drawn in the same position. The flap can be designed along the long or oblique axis of the thigh, as long as it contains vascular pedicles in the ischiorectal fossa (Fig. 4). Debridement of the ischial region was usually performed in the jackknife position.

---

**Fig. 1.** The course of the internal pudendal artery (iPa) and distribution of its skin perforators. The schema shows the features observed from the buttock side. The vascular triangle, formed by 3 points (ischial tuberosity (IT), anus, and vaginal orifice or scrotum), is placed at the ischiorectal fossa, which contains thick fatty tissue with skin perforators originating from the iPa. The iPa runs under the sacrotuberous ligament (STL) and becomes the perineal artery in the ischiorectal fossa. SSL, sacrospinous ligament.
position, with flap elevation performed in the same position. The flap was elevated from the distal to the proximal side under the deep fascia of the thigh until it was completely raised from the thigh and attached only to the ischiorectal fossa with fatty tissue (Fig. 5). A propeller-type flap can be used (Fig. 6); however, a conventional transposition-type flap is preferred because the skin bulkiness around the flap base is not noticeable in this region, and the suture line facing the anus would be contaminated by stool.

RESULTS

The patients were 3 men and 2 women, ranging in age from 29 to 80 years, with a mean age of 59 years. Partial osteotomy of the ischial tuberosity was performed in 3 patients. Propeller- and conventional transposition-type flaps were used in 1 and 4 patients, respectively. The width of all flaps ranged from 5 to 8 cm, with a mean width of 6.6 cm. The length of all flaps ranged from 10 to 17 cm, with a mean length of 12.6 cm (Table 1). The long axis of the flap was placed along the long axis of the thigh in 4 patients and along the oblique line of the thigh in 1 patient. The distal sites of all flaps were well vascularized and were de-epithelialized and buried into the defects. No complications, including flap necrosis or wound dehiscence of the donor and reconstructed sites, were observed in any patient. The follow-up period ranged from 2 to 12 months, with a mean of 5 months.

DISCUSSION

This study revealed that blood circulation of the iPap thigh flap is reliable even when careful debridement of the ischial lesion is performed, including the pressure sore, and that the flap size is adequate.

Fig. 2. Computed tomography angiography with fistulography of case 1; lateral oblique view. The right internal iliac artery (IIA) is obstructed, but the right internal pudendal artery (IPA) is enhanced with collateral circulation. Note that contrast medium (*) in the right ischial pressure sore is isolated from the perforator of the IPA (red arrow). EIA, external iliac artery; SFA, superficial femoral artery; IRA, inferior rectal artery; PA, perineal artery; R, right; L, left.

Video 1. See video, Supplemental Digital Content 1, which shows the 3-dimensional structure of the perforator vessels from the internal pudendal artery. This video is the same angiography as in Figure 2, http://links.lww.com/PRSGO/A33.
to cover an ischial pressure sore. The key anatomic characteristic of this flap is that the pedicle vessel belongs to the trunk and is very close to the reconstructed site.

Four flaps elevated from a similar donor site to the iPap thigh flap have been reported previously. These included 3 types of conventional fasciocutaneous flaps and a perforator flap, elevated from the medial thigh. The pedicle vessels of these flaps branched off from arteries of the thigh and were farther from the ischial region than the perforators of the internal pudendal artery. As the perforators of the iPap thigh flap are close to the ischial tuberosity, a long flap is not needed to cover the defect, and the portion of the flap best suited for blood circulation extends to the defect site.

Three types of perforator vessels have been proposed: indirect muscle or myocutaneous perforators, indirect septal or septocutaneous perforators, and direct perforators. The iPap flap is nourished...
Fig. 4. Case 2: a 29-year-old man developed a right ischial pressure sore because of a spinal cord injury. He underwent several surgical procedures to repair the ischial pressure sore at other hospitals. A, The iPap thigh flap is designed along the oblique axis of the thigh because the flap is easy to rotate toward the defect. The arterial sounds of a descending branch of the inferior gluteal artery are heard only at the base of the branch but not along the branch. B, Six months after the operation.

Fig. 5. Case 3: a 63-year-old man, with chronic renal failure and dialysis treatment for 13 years, developed calcinosis cutis extending to the ischial tuberosity and complained of severe pain in the sitting position. A, The lesion is resected under the deep fascia of the gluteus maximus muscle and on the periosteum of the ischial tuberosity. B, The flap is elevated completely from the muscle of the buttock and thigh. The flap pedicle attaches only to the fatty tissue of the ischiorectal fossa. A cutaneous nerve is preserved between the flap and the thigh; however, it does not contain a significant committant neurocutaneous artery contributing blood supply to the distal flap. C, Two months after the operation.

Fig. 6. Case 4: a 62-year-old woman developed a right ischial pressure sore resulting from syringomyelia. A, A propeller-type iPap thigh flap was designed after debridement of the right ischial pressure sore. B, Five months after the operation.
by the direct perforators that travel only through the fatty tissue. Other anatomical features of the skin perforators for the iPap flap are that the perforator vessels are surrounded by the thick fatty tissue in the ischiorectal fossa and that there are no fascias around the vessels, although deep fascias are found on the muscles of the buttock and thigh. During the surgical procedure to elevate the iPap flaps, aggressive dissection or skeletonization of the pedicle vessels in the ischiorectal fossa is not recommended because the vessels branch off deep within the fossa, and the flap is easy to rotate toward the defect without pedicle dissection. The vascular triangle is a good guide for finding the skin perforator. In the lithotomy position, it is easy to identify the location of the vascular triangle and the skin perforator and to locate the exact vertical axis of the thigh for designing the flap axis. Flap transplantation was performed in the jackknife position; however, no modification of the perforator location related to the position change occurred.

Blood circulation failure was not observed in any flap in the present study, as the perineal region has a thick vascular network. Furthermore, according to the recent perforasome theory, 1 perforator has the presence of the pedicle without angiography. The vascular triangle is a good guide for finding the skin perforator. In the lithotomy position, it is easy to identify the location of the vascular triangle and the skin perforator and to locate the exact vertical axis of the thigh for designing the flap axis. Flap transplantation was performed in the jackknife position; however, no modification of the perforator location related to the position change occurred.

The short distance between the ischial bone and vascular pedicle can also be a drawback of this technique given the possibility of damage to the pedicle vessels due to surgical debridement, infection, and inflammation around the ischial bone. Angiography may be needed to confirm the vascular pedicles in patients with severe vascular triangle scarring or those who have undergone several debridements of an ischial pressure sore.

The limitations of this study include the lack of follow-up for pressure sore recurrence. A fasciocutaneous flap has shown similar or better results than a musculocutaneous flap. Although we are waiting for the results of a longer follow-up period, we believe that the recurrence rate of the iPap thigh flap will not be worse than that of other fasciocutaneous flaps.

The medial region of the upper thigh has thicker fatty tissue and is easier to close than other thigh regions. This region also does not have significant vessels, nerves, or lymphatics. The pedicle vessel of the iPap flap does not arise from the thigh. This means that the flap is separated from the thigh and is not drawn back to the thigh even when the hip joint is flexed strongly in the sitting position. The iPap thigh flap is not very large, thus other thigh flaps can be raised after its elevation. However, the oblique type of iPap flap should not be elevated before the gluteal thigh flap or hamstring flap can be used. The oblique-type flap may be considered when the vascular pedicle of the gluteal thigh is damaged due to gluteus maximus muscle dissection, when skin scars are present on medial side of the thigh, or when the skin itself is too tight horizontally. A long skin paddle or muscle dissection is not required for the iPap thigh flap, which takes little time to elevate. This flap is less invasive and more suitable for elderly patients or those with complications than the gluteal thigh flap or V-Y hamstring musculocutaneous flap. The iPap thigh flap is a new option for defects of the ischial region, including ischial pressure sores, when fatty tissue around the ischiorectal fossa is intact.

Ichiro Hashimoto, MD, PhD
Department of Plastic and Reconstructive Surgery
The University of Tokushima Graduate School
3-18-15 Kuramoto
Tokushima 770–8503
Japan
E-mail: ichiro.h@tokushima-u.ac.jp

ACKNOWLEDGMENTS
We thank Tatsuya Tsuda, MD, and Atsushi Morimoto, MD, for their assistance with patient follow-up.

REFERENCES
1. Schryvers OI, Strane MF, Nance PW. Surgical treatment of pressure ulcers: 20-year experience. Arch Phys Med Rehabil. 2000;81:1556–1562.
2. Keys KA, Daniali LN, Warner KJ, et al. Multivariate predictors of failure after flap coverage of pressure ulcers. Plast Reconstr Surg. 2010;125:1725–1734.
3. Baek SM, Williams GD, McElhinney AJ, et al. The gluteus maximus myocutaneous flap in the management of pressure sores. Ann Plast Surg. 1980;5:471–476.
4. Hurwitz DJ, Swartz WM, Mathes SJ. The gluteal thigh flap: a reliable, sensate flap for the closure of buttock and perineal wounds. Plast Reconstr Surg. 1981;68:521–532.
5. Hurteau JE, Bostwick J, Nahai F, et al. V-Y advancement of hamstring musculocutaneous flap for coverage of ischial pressure sores. Plast Reconstr Surg. 1981;68:539–542.
6. Wingate GB, Friedland JA. Repair of ischial pressure ulcers with gracilis myocutaneous island flaps. Plast Reconstr Surg. 1978;62:245–248.
7. Wei FC, Celik N. Perforator flap entity. Clin Plast Surg. 2003;30:325–329.
8. Geddes CR, Morris SF, Neligan PC. Perforator flaps: evolution, classification, and applications. Ann Plast Surg. 2003;50:90–99.
9. Wei FC, Mardini S. Free-style free flaps. Plast Reconstr Surg. 2004;114:910–916.
10. Hallock GG. Doppler sonography and color duplex imaging for planning a perforator flap. Clin Plast Surg. 2003;30:347–357, v.
11. Lecours C, Saint-Cyr M, Wong C, et al. Freestyle pedicle perforator flaps: clinical results and vascular anatomy. Plast Reconstr Surg. 2010;126:1589–1603.
12. D’Arpa S, Cordova A, Pignatti M, et al. Freestyle pedicled perforator flaps: safety, prevention of complications, and management based on 85 consecutive cases. Plast Reconstr Surg. 2011;128:892–906.
13. Hashimoto I, Abe Y, Nakanishi H. The internal pudendal artery perforator flap: free-style pedicle perforator flaps for vulva, vagina, and buttock reconstruction. Plast Reconstr Surg. 2014;133:924–933.
14. Hashimoto I, Murakami G, Nakanishi H, et al. First cutaneous branch of the internal pudendal artery: an anatomical basis for the so-called gluteal fold flap. Okajimas Folia Anat Jpn. 2001;78:23–30.
15. Hashimoto I, Nakanishi H, Nagae H, et al. The gluteal-fold flap for vulvar and buttock reconstruction: anatomic study and adjustment of flap volume. Plast Reconstr Surg. 2001;108:1998–2005.
16. Baek SM. Two new cutaneous free flaps: the medial and lateral thigh flaps. Plast Reconstr Surg. 1983;71:354–365.
17. Wang TN, Whetzel T, Mathes SJ, et al. A fasciocutaneous flap for vaginal and perineal reconstruction. Plast Reconstr Surg. 1987;80:95–103.
18. Homma K, Murakami G, Fujioka H, et al. Treatment of ischial pressure ulcers with a posteromedial thigh fasciocutaneous flap. Plast Reconstr Surg. 2001;108:1990–1996.
19. Hallock GG. The propeller flap version of the adductor muscle perforator flap for coverage of ischial or trochanteric pressure sores. Ann Plast Surg. 2006;56:540–542.
20. Blondeel PN, Van Landuyt K, Hamdi M, et al. Perforator flap terminology: update 2002. Clin Plast Surg. 2003;30:343–346.
21. Salmon M. The external genitalia and the perineum. In: Taylor GI, Tempest MN, eds. Arteries of the Skin. Edinburgh: Churchill Livingstone; 1988:109–127.
22. Saint-Cyr M, Wong C, Schaverien M, et al. The perforated parameum theory: vascular anatomy and clinical implications. Plast Reconstr Surg. 2009;124:1529–1544.
23. Yamamoto Y, Tsutsumida A, Murazumi M, et al. Long-term outcome of pressure sores treated with flap coverage. Plast Reconstr Surg. 1997;100:1212–1217.
24. Thiesen FE, Andradas P, Blondeel PN, et al. Flap surgery for pressure sores: should the underlying muscle be transferred or not? J Plast Reconstr Aesthet Surg. 2011;64:84–90.