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ORIGINAL ARTICLE SPECIAL TOPICS

Shortening of Incision by "Pinch and Turn-Over Technique" in the Treatment of Axillary Osmidrosis

Eui-Tae Lee[1]

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Abstract

Background The pinch and turn-over technique was developed to minimize the incision in the manual subdermal excision of apocrine glands in axillary osmidrosis for the best cure and fewest complications.

Methods Through a 2-cm-long incision, peripheral subdermal tissue was excised by the technique under direct vision using intravenous anesthesia and tumescent technique. Ninety-nine axillae in 50 patients including seven secondary cases were operated on from 2009 to 2018. Long-term follow-up (average 30.3 months) could be done on 40 patients with questionnaires consisting of four-point ordinal-scale questions regarding osmidrosis grade, hyperhidrosis grade and satisfaction. For systematic review regarding incision length, 220 articles from 1962 to 2018 were reviewed with the search terms "osmidrosis" or "bromhidrosis."

Results Thirty-five and 30 of 40 respondents (87.5% and 75.0%) had excellent or good postoperative results in osmidrosis and hyperhidrosis grade. Postoperative improvement of osmidrosis grade (from 2.53 to 0.80) and hyperhidrosis grade (from 1.88 to 0.95) was statistically significant ($p < 0.01$). Thirty-four patients (85.0%) reported very satisfactory or satisfactory. Hematoma (2.0%), hyperpigmentation (5.0%), infection (5.0%) and noticeable scar (2.5%) were rare. Necrosis of flap margins was frequent (27.3%) but necessitated revision in two cases (2.0%). Among eleven articles found to describe incision length in pure manual subdermal excision, this technique provided the shortest incision compared with eight direct subdermal excision methods with an average incision length of 5.0 cm.

Conclusions This technique offers an open, direct and selective approach with a short incision. It could maintain the best efficiency while neutralizing negative side effects of conventional manual subdermal excision for axillary osmidrosis.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these evidence-based medicine ratings, please refer to the table of contents or the online instructions to authors www.springer.com/00266.

Keywords Osmidrosis · Bromhidrosis · Hyperhidrosis · Subdermal excision · Pinch and turn-over technique

Introduction

Axillary osmidrosis or bromhidrosis is characterized by unpleasant odor due to bacterial decomposition of excessive sweat secretion from apocrine sweat glands. It causes difficulty in social activities and personal handicap which might be even more distressing in a crowded urban lifestyle. According to that late socio-environmental change, there is a rising demand for treatment in mildly symptomatic patients and they expect more complete removal of odor. Nonsurgical methods such as topical antiperspirants, needle electrocoagulation and botulinum toxin injection could be used but with limited and temporary effects.

Surgical treatment is thus warranted to reduce apocrine gland mass permanently. Manual subdermal excision is a time-tested standard surgical method of axillary osmidrosis

✉ Eui-Tae Lee
etlee@chungbuk.ac.kr

[1] Department of Plastic and Reconstructive Surgery, Chungbuk National University College of Medicine, 1, Chungdae-Ro, Seowon-gu, Cheongju, Chungbuk 28644, Korea

with the best cure rate because of direct exposure and selective removal of apocrine and eccrine sweat glands [1–4]. But it also has many drawbacks such as hematoma, seroma, wound dehiscence, flap necrosis, infection and a long scar [4, 5]. To maintain the efficiency of the direct approach while neutralizing the negative side effects associated with a long incision, the author treated axillary osmidrosis by pinching the flap and turning it over for piecemeal removal of glandular tissue through a short incision of 2 cm.

Materials and Methods

Patients (Tables 1, 2)

In this retrospective case series, 99 axillae in 50 patients underwent short scar manual subdermal excision using the pinch and turn-over technique from November 2009 to February 2018. Twenty-four male patients and 26 female patients ranged in age from 12 to 58 years old (mean = 23.6). In one unilateral operation case, profuse intraoperative bleeding made a conventional 45 mm incision inevitable. As an indication of surgery, patients with osmidrosis grades 2–3 were considered as candidates for the operation (fair or poor in Table 1) [1]. For short-term complications within 6 months after surgery, monitoring was done through admission and outpatient clinic. Long-term follow-up (at least 6 months, average 30.3 months) could be done on 40 of 50 patients with questionnaires through preoperative face-to-face interviews and postoperative telephone interviews. Ten patients were lost to follow-up due to telephone number change or rejection. The demographic data of respondents were not different from the original patient population. Questionnaires for preoperative interviews consisted of four-point ordinal-scale questions (excellent, good, fair, poor) in two categories regarding osmidrosis and hyperhidrosis grades. Items from the questionnaires were modified from a previously reported osmidrosis grading system and hyperhidrosis grading system [1]. For questionnaires for postoperative telephone interview, three categories regarding osmidrosis and a hyperhidrosis grades and patient satisfaction (very satisfied, satisfied, neither satisfied nor dissatisfied, very dissatisfied) were surveyed. For those who were neither satisfied nor dissatisfied and very dissatisfied, a further question was asked as to whether they regretted having surgery or not. Recurrence was defined as postoperative odor the same or worse than osmidrosis grade 2. Ten difficult cases of this series included seven secondary cases (one skin and subcutaneous en bloc excision, one manual subdermal excision, four suctions, one laser) and two other previous axillary operation cases (one dermofat graft harvest, one endoscopic thoracic sympathectomy for palmar hyperhidrosis) and one patient with burn scars around the right shoulder, arm and chest (Table 2). A total of 18 axillae (two unilateral cases in one dermofat graft harvest and burn scars) belonged to this group. As seen in Table 1, ten family members from five families were included in the study.

The Wilcoxon matched-pairs signed-rank test was used to compare preoperative and postoperative degrees of osmidrosis and hyperhidrosis. Fisher's exact test was used to compare the effect of operation for osmidrosis and hyperhidrosis between ten difficult cases and others. A p value < 0.05 was considered statistically significant. Statistical analysis was performed using SPSS version 24 software (SPSS Inc., Chicago, IL, USA).

Systematic Review

A systematic review regarding incision length in manual subdermal excision was performed. The author searched articles in the English and Korean languages based on PubMed and KorMed searches using the database from 1962 to 2018 with search terms "osmidrosis" or "bromhidrosis." Scientific papers that precisely described the incision length in pure manual subdermal excision were compared with the pinch and turn-over technique (Table 3). Procedures involving skin excision, alternative less invasive techniques and combined methods were excluded.

Surgical Techniques

The patient was placed in a supine position with both arms abducted from the trunk to approximately 90 degrees on arm boards. Arms were tied securely to arm boards in preparation for agitation during intravenous anesthesia, but shoulders should be movable for later adduction during the operation. After intravenous anesthesia with an initial bolus injection of Ketamine 0.5 mg/kg and Propofol 1.2 mg/kg followed by Propofol 6 mg/kg/hr continuous infusion, the proposed area of operation was marked 1 cm beyond the hairline. An initial infiltration of 15–20 cc of 1% Lidocaine was followed by 200 cc of tumescent solution (Ringer's lactate with 8 cc of 2% Lidocaine and 0.4 cc of 1:1000 epinephrine) on each axilla. A 2-cm transverse incision was made at the apex of each axillary fossa asymmetrically. On the right axilla, the incision was performed 5 mm proximally from the midaxillary crease to facilitate exposure of the flap base by retraction with the operator's non-dominant left hand. The incision was made 5 mm distally from the midaxillary crease on the left side (Fig. 1). After subcutaneous dissection according to the intraoperative marking, the central subdermal tissue was exposed by the

Table 1 Patients' summary, subjective long-term evaluations by interview (elimination of odor, sweating, satisfaction and long-term complications) and objective short-term evaluations by monitoring (short-term complications)

Total number of patients	50 (male 24, female 26)
Total number of operated axillae	99 (intraoperative conversion to longer incision d/t bleeding 1)
Average age	23.6 years (12–58 years)
Respondents of telephone interview	40/50 (80%, male 19, female 21, average age 23.1 years)
Average postoperative follow-up	30.3 months
Remarks	
Relatives	10 members from 5 families
Difficult cases	10/50[a]
Reoperation case	7
Previous other axillary operation	2 (3 axillae)
Burn in shoulder, chest and arm	1 (1 axilla)
Osmidrosis grade (preop /postop average):	2.53/0.80[b]
Excellent (0% = grade 0) preop /postop no. of patients	0/15
Good (only on excessive perspiration = grade 1) preop /postop	0/20
Fair (reduced but even in daily activities = grade 2) preop /postop	19/3
Poor (100% = grade 3) preop /postop	21/2
Hyperhidrosis grade (preop /postop average):	1.88/0.95[c]
Excellent (0% = grade 0) preop /postop no. of patients	5/13
Good (only when excessive perspiration = grade 1) preop /postop	5/17
Fair (reduced but even in daily activities = grade 2) preop /postop	20/9
Poor (100% = grade 3) preop /postop	10/1
Patient's satisfaction	
Very satisfied (VS)	22 (55.0%)
Satisfied (S)	12 (30.0%)
Neither satisfied nor dissatisfied (NSND)	3 (7.5%)
Very dissatisfied (VD)	3 (7.5%)
Regret for operation	2 (5.0%)
Short-term complications (within 6 months)	
Hematoma	2/99 (2.0%)
Skin margin necrosis	27/99 (27.3%)
Revision	2/99 (2.0%)
Subdermal tethering	3/99 (3.0%)
Long-term complications (after 6 months)	
Recurrence	5/40 (12.5%)
Hyperpigmentation	2/40 (5.0%)
Infection	2/40 (5.0%)
Scar	1/40 (2.5%)

[a]Details of the ten difficult cases are described in Table 2

[b,c]Significantly lower postoperative osmidrosis grade and hyperhidrosis grade compared with preoperative grades ($p < 0.01$, Wilcoxon matched-pair signed-rank test)

conventional finger eversion technique and excised as en bloc using a no. 15 blade to reduce the operation time (Figs. 2, 3). For peripheral tissue, the flap undersurface was exposed by the pinch and turn-over technique after adduction of the arm to 75 degrees (Figs. 2, 4). The central flap was pinched between the thumb and index finger like a pinch test during liposuction and the apocrine gland laden peripheral flap undersurface was turned over and pushed through the incisive opening by the middle finger. Pinch and turn-over got easier as the central flap was already thinned during the finger eversion technique and patient's arm was adducted slightly to decrease tension. Well-exposed subdermal sweat gland tissue on peripheral flap undersurface was excised as piecemeal by curved sharp

Table 2 Details of ten difficult cases

Difficult cases	10/50 (male 6, female 4)
Average age	27.0 years (15–49 years)
Respondents of telephone interview	8/10 (80%, male 5, female 3)
Average postoperative follow-up	19.6 months
Compromising factors	
Reoperation case	7
Previous other axillary operation	2 (3 axillae)
Burn in shoulder, chest and arm	1 (1 axilla)
Osmidrosis grade (preop /postop average)	2.75/1.0[a]
Excellent (0% = grade 0) preop/postop no. of patients	0/2
Good (only on excessive perspiration = grade 1) preop/postop	0/5
Fair (reduced but even in daily activities = grade 2) preop/postop	2/0
Poor (100% = grade 3) preop/postop	6/1
Hyperhidrosis grade (preop/postop average)	1.88/1.25[b]
Excellent (0% = grade 0) preop/postop no. of patients	1/1
Good (only when excessive perspiration = grade 1) preop /postop	0/4
Fair (reduced but even in daily activities = grade 2) preop/postop	6/3
Poor (100% = grade 3) preop/postop	1/0
Patient's satisfaction	
Very satisfied (VS)	5
Satisfied (S)	2
Neither satisfied nor dissatisfied (NSND)	0
Very dissatisfied (VD)	1
Regret for operation	1
Short-term complications (within 6 months)	
Hematoma	2/18 (11.1%)
Skin margin necrosis	5/18 (27.8%)
Revision	0/18 (0%)
Subdermal tethering	1/18 (5.6%)
Long-term complications (after 6 months):	
Recurrence	1/8 (12.5%)
Hyperpigmentation	1/8 (12.5%)

[a,b]No significant difference of postoperative osmidrosis grade improvement ($p = 0.393$, Fisher's exact test) and postoperative hyperhidrosis grade improvement ($p = 1.000$, Fisher's exact test) between eight respondents in ten difficult cases and 32 other respondents

Table 3 Incision lengths in pure manual subdermal excision without skin excision and special instrumentation excluding less invasive techniques and combined methods

Author	Incision types	Incision lengths (cm)	Exposure
Yoo [8]	Single incision	4	Direct
Tung and Wei [9]	Two transverse incisions	6 (3 cm × 2)	Direct
Park and Shin [1]	Single incision	4–6	Direct
Ha et al. [3]	Single incision	4–5	Direct
Yim et al. [10]	Offset cruciate incision	6–7 (4 cm + 1 − 1.5 cm × 2)	Direct
Ahn [11]	Single incision	3.5–4	Direct
Liu et al. [12]	Single incision	2	Blind
Liu et al. [13]	Single incision	1	Blind
Ding and Zheng [14]	Single incision	1/4–5	Blind/Direct
Zhao et al. [15]	Single incision	1.5	Unclear
Shin et al. [16]	1–2 transverse incisions	3–8 (3–4 cm × 1–2)	Direct

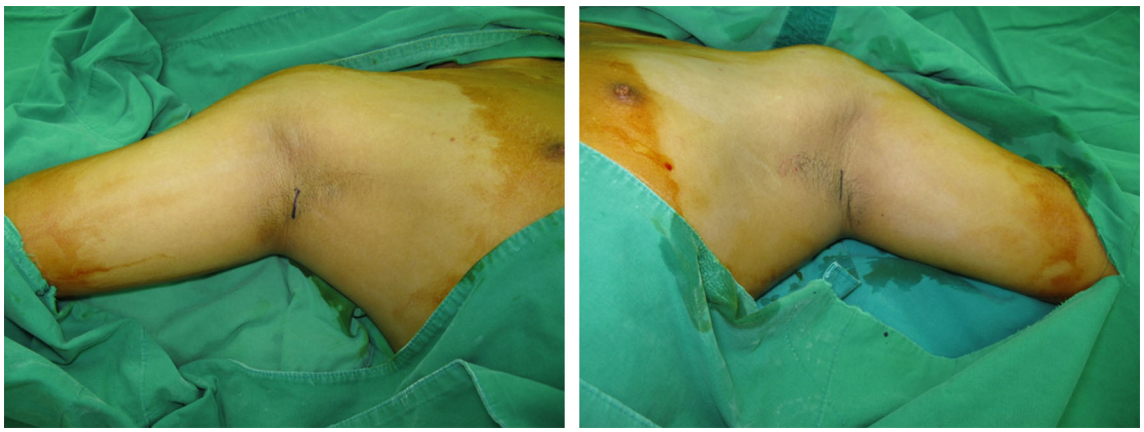

Fig. 1 Short transverse eccentric single incision (Left) on right axilla, 2-cm length transverse incision was marked 5 mm proximally from midaxillary crease to facilitate exposure of flap base by non-dominant left hand. (Right) Same length incision was marked 5 mm distally from midaxillary crease on left side

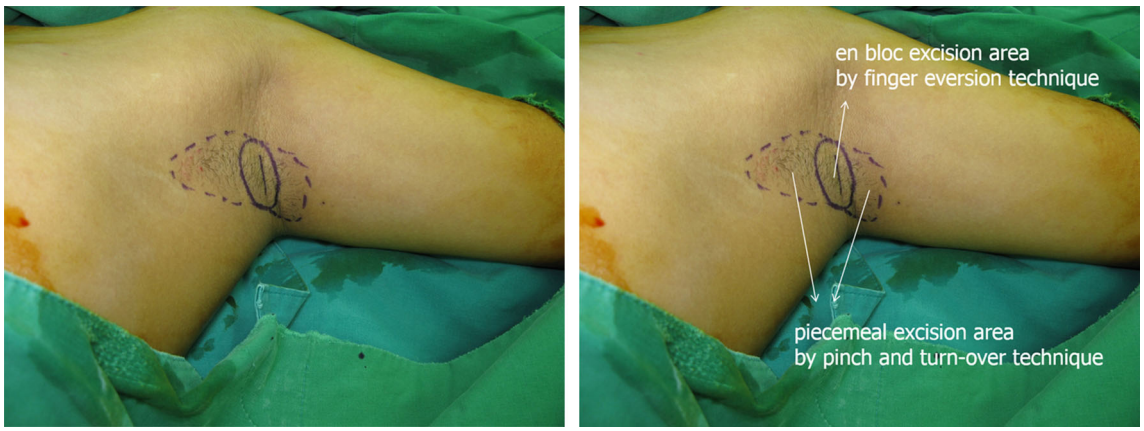

Fig. 2 (Left) Area of subdermal tissue excision. Inner round circle indicates en bloc excision area by finger eversion technique and outer stippled ellipse indicates piecemeal excision area by pinch and turn-over technique. (Right) Schematic presentation

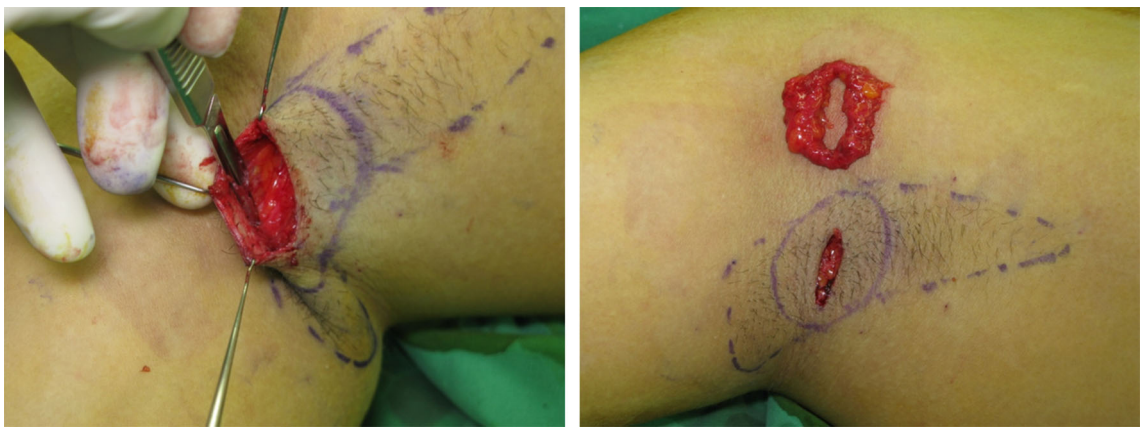

Fig. 3 Finger eversion technique at the center. (Left) The finger eversion technique was done at the center using a no. 15 blade. (Right) Central subdermal tissue was excised as en bloc to hasten the operation speed

scissors under direct vision. Visible subdermal vessels were preserved during the removal of the gland (Fig. 5). A faint purpura skin color was a useful indicator when trimming was adequate. Profuse irrigation, electrocoagulation, fibrin glue spray, and insertion of a Penrose drain followed. Bipolar electrocoagulation was done only on the

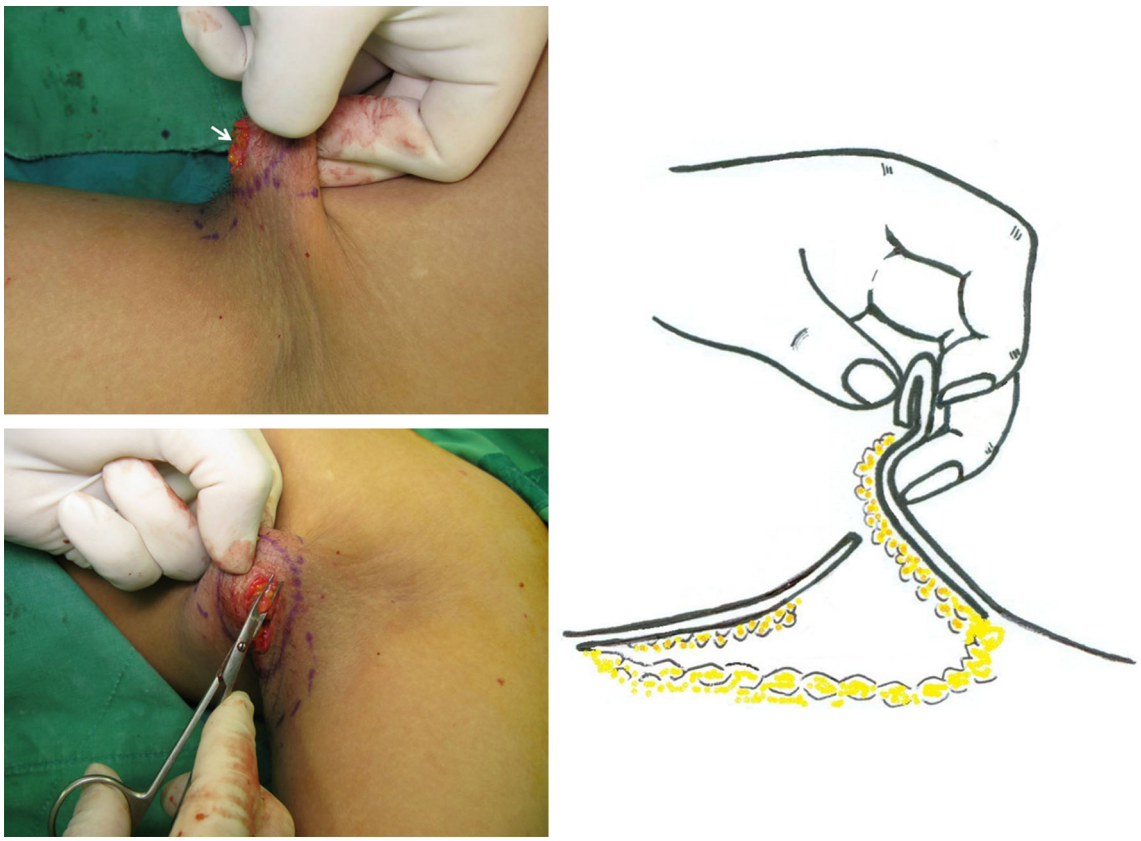

Fig. 4 Pinch and turn-over technique at the periphery. (Left Above) After pinch of the central flap by thumb and index finger, the peripheral flap undersurface (arrow) was turned over and pushed through the incisive opening by the middle finger. (Left Below) Exposed peripheral subdermal tissue on flap undersurface was excised as piecemeal by curved scissors under direct vision. (Right) Schematic presentation

Fig. 5 A large subdermal vessel was preserved along its horizontal path from left to right direction

Fig. 6 Immediate postoperative view. A drainage tube and three tacking sutures including a buried suture at the central incision line were placed to prevent dead space and hematoma. A faint purpura skin flap color was a useful indicator of when to stop trimming

axillary fascia side skipping the skin flap undersurface. Incisions were closed with continuous sutures. Three tacking sutures including a buried suture at the central incision line were placed between the skin flap and axillary fascia to obliterate dead space (Fig. 6). A figure-of-eight compressive dressing with bulky gauze and elastic bandage was applied. During application of the dressing, the patient was advised to clench and open his fists repeatedly and report numbness of hands to prevent too much compression. The patient was admitted to hospital for 3 days to

avoid shoulder movement and to supply oxygen 10 L/min via a facial mask with a reservoir bag. The Penrose drain, compressive dressing and sutures were removed on the 3rd, 7th and 14th postoperative days, respectively. The patient was allowed to take a shower after removal of the dressing but was advised to avoid full abduction of the arms for 2 weeks. He was also taught to avoid direct sun exposure and apply sunblock cream daily for 6 months.

Results

The demographic characteristics and objective evaluation of short-term complications in 50 patients, and subjective evaluation of long-term effectiveness in the elimination of odor, sweating, satisfaction and long-term complications in 40 respondents are summarized in Table 1 and Fig. 8.

With respect to odor, 35 of 40 patients (87.5%) had excellent or good results without recurrence during the follow-up period of six to eighty-four months with a mean of 30.3 months (Fig. 7). For reduction of sweating, 30 patients (75.0%) had excellent or good postoperative results. The preoperative average osmidrosis grade 2.53 and hyperhidrosis grade 1.88 improved to 0.80 and 0.95 postoperatively. Thirty-four patients (85.0%) reported the operation as being very satisfactory (55.0%) or satisfactory (30.0%). Five recurrent cases (postoperative osmidrosis grade 2–3) and one patient who complained about prolonged recovery time reported it neither satisfactory nor dissatisfied (7.5%) or very dissatisfactory (7.5%). Among them, two patients (5.0%) regretted having surgery. The Wilcoxon matched-pairs signed-rank test revealed that osmidrosis grade and hyperhidrosis grade improved significantly after the operation ($p < 0.01$).

In the early postoperative period, skin necrosis of flap margins was frequent (27/99 = 27.3%) but necessitated revision only in two cases (2/99 = 2.0%). It was successfully treated with minimal debridement and antibiotic ointment application at the outpatient clinic. In two revision cases, debridement was followed by full-thickness skin graft in one case (after the trial of 85% alcohol for 3 min) [6] and primary closure in the other case. Two hematoma cases (2/99 = 2.0%, secondary cases after liposuction and endoscopic thoracic sympathectomy) were aspirated and healed without sequelae. A mild subdermal tethering band was noted in three cases (3/99 = 3.0%, one after hematoma, one after marginal flap necrosis), but it disappeared spontaneously after 6 months [7]. As long-term side effects, five recurrences (5/40 = 12.5%), two hyperpigmentations (2/40 = 5.0%), two infections (2/40 = 5.0%) and one noticeable scar (1/40 = 2.5%) were noted. One cellulitis was successfully treated with oral antibiotics and one abscess which might be superimposed on an epidermal cyst healed after incision and drainage. One scar-related problem was noted in the full-thickness skin graft case.

Fig. 7 Long-term follow-up view. 13 months after surgery, scar was not noticeable along with disappearance of odor and sweating

As to ten difficult cases (seven secondary cases, two previous other axillary operation cases and one adjacent burn scar case), eight patients except one previous suction and one burn scar case could be followed up. In this group, the preoperative average osmidrosis grade 2.75 and hyperhidrosis grade 1.88 improved to 1.00 and 1.25 after the operation. Five, two and one patients were very satisfied, satisfied and very dissatisfied, respectively. One very dissatisfied patient got her second recurrence here. Two hematomas (2/18 = 11.1%), five marginal flap necrosis (5/18 = 27.8%), one subdermal tethering (1/18 = 5.6%) and one hyperpigmentation (1/8 = 12.5%) were noted in the group. The effect of surgery was not significantly different between the eight respondents in the difficult cases group and the 32 others according to Fisher's exact test in both osmidrosis grade and hyperhidrosis grade ($p = 0.393$, $p = 1.000$ respectively).

Among 220 articles sought on the PubMed and KorMed databases from 1962 to 2018 with search terms "osmidrosis" or "bromhidrosis," 11 articles (12 techniques) were found to precisely describe the incision length in pure manual subdermal excision without skin excision excluding alternative less invasive techniques and combined methods. Those techniques are classified into eight direct methods, three blind methods and one unclear method. In eight direct methods, the incision ranges from a single 3.5-cm-long incision to an offset cruciate incision of 6–7 cm length with an average length of 5.0 cm (Table 3) [1, 3, 8–16]. The 2 cm length of incision in pinch and turnover technique is the shortest among direct subdermal excisions.

Discussion

Since Skoog and Thyresson's report in 1962, open manual subdermal excision of apocrine glands has been the standard treatment for axillary osmidrosis [1–5]. Recently, less invasive techniques such as ethanol irrigation or injection [6, 17], suction-assisted lipectomy [18], superficial liposuction [19] and endoscopic shaving [20] were introduced and utilized frequently. Those alternative techniques were initially developed as means of soft tissue ablation and have common advantages of less invasiveness, lower complication rates and shorter operation and convalescent time. But, they require special instrumentation and result in a higher recurrence rate compared to manual subdermal excision (13.6–46.9% vs. 7.7%, 5% vs. 0%, 7.7–8.2% vs. 3.6% according to Park and Shin, Ha et al. and Shin et al., respectively). [1, 3, 4]. A small number of apocrine glands located in the dermis and dense fibrous septae adhered to the skin at the central area limit the efficacy of those procedures [1, 19]. In contrast, subdermal excision has an excellent result in terms of gland removal but with many complications such as hematoma, wound dehiscence, flap necrosis and a long scar. The author assumes these problems to over invasiveness of the subdermal excision, in which a long incision and complete destruction of the subdermal vessels leads to more bleeding and problems in wound healing.

To address those shortcomings, the author limited the length of the incision to 2 cm. Those short transverse incisions were placed asymmetrically on each axillary apex 5 mm from the center away from the non-dominant retracting hand to assist the exposure (short eccentric single transverse incision, Fig. 1). After excision of the central subdermal tissue by the conventional finger eversion technique, the peripheral tissue beyond reach with 2-cm-long incision was exposed by the pinch and turn-over technique and excised as piecemeal under direct vision (Figs. 2, 3, 4). The central flap was ready to be pinched and turned over after asymmetrical placement of incisions, already thinned central flap skin and reduced tension according to arm adduction. By doing so, the 2-cm incision is enough to ablate peripheral gland tissue.

In the author's opinion, manual subdermal excision techniques can be classified as direct methods and blind methods according to exposure and then as single lineal incision methods [1, 3, 8, 11–16], double lineal incision methods [5, 9, 16], angled incision methods [7, 10, 21] and curved incision methods according to incision types.

Through systematic review of 220 articles in the English and Korean languages, 11 articles (12 techniques) were found to precisely describe incision length in pure manual subdermal excision methods. Those techniques were categorized into eight direct methods, three blind methods and one unclear method. Among the direct methods, the incision ranges from a single 3.5-cm-long incision to an offset cruciate incision of 6–7 cm length with an average length of 5.0 cm (Table 3) [1, 3, 8–11, 14, 16]. The pinch and turn-over technique minimized the incision length among direct subdermal excisions. The author did not experience any scar-related problem except one full-thickness skin graft case during follow-up. One article [15] reported a shorter 1.5-cm-long mini-incision but lacked a precise description of how to expose the peripheral flap undersurface. Even whether the direct or blind method was not clear and it ended up as persistent malodor (6.2%), hematomas (10.2%) and many other complications.

Along with the merit of a short incision, visible subdermal vessels were preserved as much as possible to prevent too invasive tissue destruction and thus bleeding and wound healing problems (Fig. 5). A true flap incorporating some visible subdermal vessels rather than the old 'flap to graft conversion' principle took an advantage of the open direct approach, in which precise control of resection might result in decreased risk for skin necrosis and wound dehiscence. According to Kim et al. [2], an 81.25% patient satisfaction rate was observed despite only 57% of apocrine glands being removed with superficial liposuction compared with subdermal excision. In consideration of this moderately satisfactory result with less complete removal, it is reasonable to save large subdermal vessels at the expense of thin surrounding glandular tissue remaining.

As a response to postoperative questionnaires, most patients reported excellent or good osmidrosis grades (87.5%) and hyperhidrosis grades (75.0%). Postoperative changes of osmidrosis grade (average 2.53–0.80) and hyperhidrosis grade (average 1.88–0.95) revealed significant improvement by statistical analyses ($p < 0.01$). In spite of some short and long-term complications and longer recovery time, only two patients (2/40 = 5.0%) regretted having the surgery when asked if they would undergo the same operation again. This positive appraisal was also indirectly expressed as ten family members from five families were included in the study (Table 1, Fig. 8).

Even with meticulous bleeding control by headlamp and bipolar electrocoagulation, hematoma formation is a potential threat because cautery was performed only on the axillary fascia side exempt from the flap undersurface to avoid subdermal vessel damage. Therefore, a Penrose drain, three tacking sutures between the skin flap and axillary fascia, fibrin glue spray [22] and figure-of-eight compressive dressings were applied. These measures also could obliterate the dead space. With those preventive measures, the author experienced two hematoma cases (2/99 = 2.0%) only in secondary cases after liposuction and

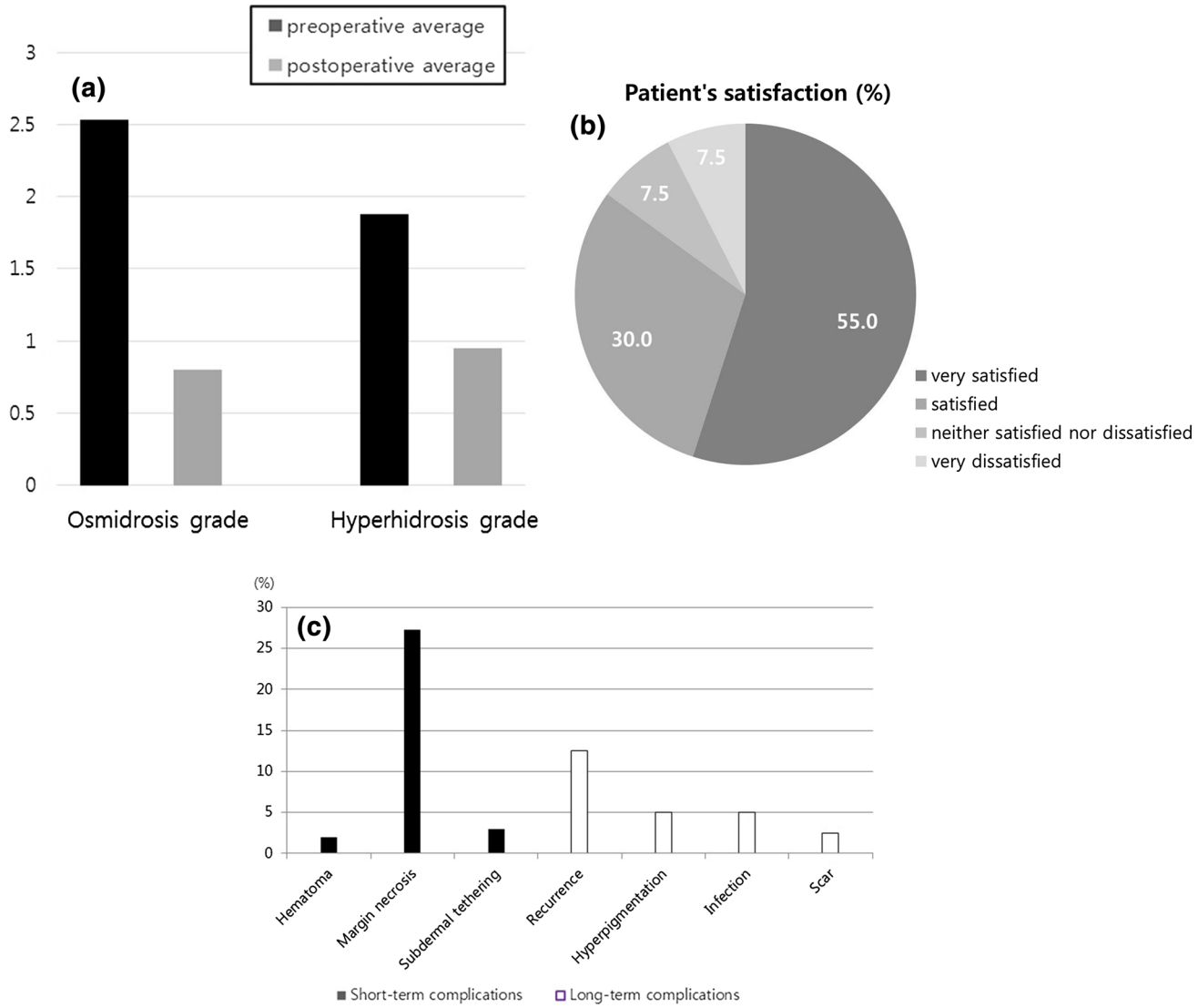

Fig. 8 The efficiency and complications of the pinch and turn-over technique. **a** Postoperative reduction of average osmidrosis grade/hyperhidrosis grade from 2.53/1.88 to 0.80/0.95. Statistical analysis disclosed that the differences were significant ($p < 0.01$, Wilcoxon matched-pair signed-rank test). **b** Distribution of patient satisfaction; 85.0% were very satisfactory or satisfactory. **c** Incidences of short-term and long-term complications. Skin necrosis of flap margins was frequent (27.3%), whereas other complications are rare. It was successfully treated with minimal debridement and antibiotic ointment application except two revision cases

endoscopic thoracic sympathectomy which were aspirated and healed without sequelae.

Though hematoma (2/99 = 2.0%), hyperpigmentation (2/40 = 5.0%), infection (2/40 = 5.0%) and scar-related problems (1/40 = 2.5%) were rare, skin necrosis of flap margin was the most frequent complication (27/99 = 27.3%) even with preservation of subdermal vessels. So, the patients were admitted to the hospital for 3 days to avoid shoulder movement and to apply oxygen 10 L/min via a facial mask with a reservoir bag but without much improvement. At the beginning of this series, the same amount of 1% lidocaine and 0.2% ropivacaine was mixed with 1:200000 epinephrine for local infiltration and resulted in frequent marginal necrosis of flaps and intraoperative pain. As the study progressed, the concentration of epinephrine was reduced to 1:400000 and then most recently, 15–20 cc of 1% lidocaine only solution without epinephrine and 200 cc of tumescent solution were used on each axilla without any marginal necrosis and hematoma. A future confirmative study at a large scale is needed.

Although the frequency was high, skin necrosis was usually minor and did not compromise the final result with no need for further surgical revision. Previously, some surgical methods [23, 24] adopted excision of skin up to 3 cm width with its glandular tissue underneath and resulted in reasonably successful outcomes. In

consideration of the large amount of spare skin in the axilla, intentional trimming of a shallow strip of marginal skin stressed during the operation could also reduce postoperative marginal flap necrosis in future trials.

In one of two revision cases, a trial of 85% alcohol irrigation for more complete ablation of malodor resulted in severe skin necrosis probably due to internal burn and ended in a long-term complication of full-thickness skin graft scar. Therefore, high concentration alcohol irrigation should be abandoned in this type of open direct manipulation of subdermal tissue. Two cases of hyperpigmentation were noted early in the series and avoidance of sun exposure and daily application of sunblock cream for 6 months were recommended routinely thereafter.

For eight respondents from ten difficult cases, the preoperative average osmidrosis grade 2.75 and hyperhidrosis grade 1.88 improved to 1.00 and 1.25 postoperatively with two hematomas (2/18 = 11.1%), five marginal flap necroses (5/18 = 27.8%), one subdermal tethering (1/18 = 5.6%), one recurrence (1/8 = 12.5%) and one hyperpigmentation (1/8 = 12.5%). The effect of the operation was not significantly different between the difficult cases group and others on statistical analyses without increment of short- and long-term complications (Table 2).

At present, the need for admission and long operation time up to 2 hours are major limitations of this pinch and turn-over technique. In consideration of the high complication rate of marginal skin necrosis, the author made admission routine. But, several compliant patients with small operation areas could be managed on an outpatient clinic basis with recent adoption of lidocaine only infiltration and the tumescent technique. The author used a no. 15 blade for en bloc removal of the central subdermal tissue to reduce operation time (Fig. 3). As experience accumulates, the operation time would shorten.

As of now, the author would like to narrow the strong indication for surgery to patients who seek maximal removal of apocrine and eccrine glands, such as severe osmidrosis, axillary hyperhidrosis, before marriage or enrollment, and secondary operation considering cost and risk to benefit ratio. Especially in recurrent cases after less invasive techniques, in which a surgeon has to use a scalpel to dissect off postoperative adhesions and the patient wants to limit the operative scar, this technique could be the best option. Seven secondary cases of this series were successfully treated with the pinch and turn-over technique except one recurrence. Conversely, in an institution that does not have special instrumentation for less invasive techniques, this technique could bring the best result in an economical way.

There exists a dilemma between the efficiency of sweat gland removal and the risk of complications in the treatment of axillary osmidrosis [21]. The more complete sweat gland removal, the more frequently and severely complications develop. We should keep balance between the two objectives but could deliberately put weight on one end of the spectrum. While nonsurgical methods leave fair odor but without serious complication, less invasive techniques give good reduction of odor with mild complications. Manual subdermal excision offers the most effective treatment of malodor but with moderate complications. All three major types of treatment have their own merits under certain circumstances and should be included in the armamentarium of surgeon. The author would like to add a new option to the manual subdermal excision method. In exchange for possible minor skin necrosis and longer recovery time, some patients would prefer the pinch and turn-over technique which achieves the ultimate goal of maximal odor eradication without fear of scar and poor healing.

Conclusions

The pinch and turn-over technique offers an open, direct and selective approach to axillary subdermal tissue with a short incision. It could maintain the best efficiency while neutralizing the negative side effects of conventional manual subdermal excision for axillary osmidrosis. Those who seek maximal removal of apocrine and eccrine glands, such as severe osmidrosis, primary axillary hyperhidrosis, persons before marriage or enrollment and secondary cases would be benefitted.

Compliance with Ethical Standards

Conflicts of interest No conflicts of interest were declared.

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