Bromhidrosis Treatment Modalities: A Literature Review

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Title: Bromhidrosis Treatment Modalities: A Literature Review

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ABSTRACT

Background: Treatment options for Bromhidrosis include Botulinum toxin therapy, microwave-based therapy, laser therapy, and surgerical intervention. There have been limited studies comparing their efficacies.

Objective: The purpose of this literature review is to compare the efficacy and safety of these treatments for bromhidrosis.

Methods: A PubMed search included terms “Bromhidrosis” and “Bromhidrosis AND Treatment”.

Results: A total of 25 articles were reviewed. Botulinum toxin therapy shows consistent benefit, but requires repeated therapies. Microwave therapies have shown promising results, but require larger cohort sizes with bromhidrosis. Similarly, laser therapy has shown promise with biopsy-proven results, but long lasting effects remain unknown. Surgery has the best long-term prognosis, but the ideal surgical method remains unknown.

Limitations: Each study varied in their treatment interval and method of assessing bromhidrosis, making direct comparisons difficult.

Conclusions: Managing bromhidrosis requires shared-decision making with the patient. Mild to moderate symptoms may be managed initially with Botulinum toxin therapy. In cases that are refractory, laser therapy should be considered as it is better studied than microwave therapy currently. Lastly, if the condition is severe and refractory to other options, surgery can be considered although the ideal method remains unknown.

Capsule Summary
• This article details the variety of options available for the treatment of bromhidrosis.
• Providers should understand the various treatment options available and provide the best course of action in line with the patient's wishes and severity of disease.
INTRODUCTION

Disorders of the sweat gland impact quality of life. Bromhidrosis is characterized by bacterial breakdown of apocrine secretions leading to unpleasant body odors. In recent years, various therapeutic modalities have been developed to help address these concerns. This article will aim to provide a review of the current treatment options for bromhidrosis.

Three distinct forms of sweat glands visible by histology: eccrine, apocrine, and apoeccrine. Although bromhidrosis is more associated with apocrine gland secretions, excessive amounts of eccrine secretions create a moist environment that may help promote bacterial proliferation.

Apocrine glands are present at birth but only achieve functional status upon puberty. They are found mainly in the armpit, areola, perineum, ear, and eyelids. Single-nucleotide polymorphisms in the ABCC11 gene which encodes for proteins in the apocrine gland were associated with bromhidrosis.

A third kind of gland – the apoeccrine glands takes on features of both eccrine and apocrine glands. By the ages of 16-18 years of age, apoeccrine gland concentration increases to compose as much as 45% of the total axillary glands.
Methods

A search was performed in PubMed. Phrases included “Bromhidrosis,” and “Bromhidrosis AND treatment. A total of 53 articles were found. Our search period spanned from 2000 to 2020. A total of 45 articles remained. These articles were then assessed for relevance and quality by the authors. Only studies published in English and involving human subjects were included. 25 of these articles were included as part of this review.

Articles were selected as relevant if they 1) were prospective or retrospective studies or meta-analyses involving patients with complaints of malodor or confirmed bromhidrosis and 2) involved interventions related to the treatment of bromhidrosis. Articles were excluded if they 1) were case abstracts or expert opinion articles; or 2) did not include an analysis of bromhidrosis disease activity.
RESULTS

Hygiene and Topical Agents

Hygiene modification and topical agents are first-line therapies. Such measures include showers, laundering, antiperspirant application, and not reusing dirty clothes. Recently, lemon juice application was noted to suppress malodor.\(^5\)

Most antiperspirants contain metallic salts, mainly aluminum, that exhibit antibiotic properties. Aluminum polymerizes in alkaline environments forming plugs in the sweat duct that temporarily block the movement of secretions. The acidic nature of aluminum, however, can be irritating to the skin. To combat this, a formulation consisting of salicylic acid and aluminum was devised with additional anti-bacterial and antifungal properties.\(^6\) Regular shaving and laser hair removal options also exist. Interestingly, cases of generalized bromhidrosis have been reported following whole-body laser hair removal.\(^7\)

Topical antibiotic therapy is also possible. Antimicrobial metal ions, also known as antimicrobial ceramics have shown antimicrobial benefits and are considered safer and more durable than topical antibiotics.\(^8,9\) These topical antimicrobials decrease the bacterial burden on the skin surface but increase bacterial resistance. Therefore, topical antimicrobial use should be minimized unless other antiseptic options have proven ineffective.

BTX-A Therapy

Botulinum toxin A (BTX-A) acts on the presynaptic terminal of the neuromuscular junction to prevent the release of acetylcholine (ACh). It has a wide variety of
uses including treat cervical dystonia, headaches, spasticity, migraines, blaphrospasm and more recently bromhidrosis. In a 2003 study, 16 healthy volunteers were recruited. All were noted to have significant malodor. Volunteers were injected with BTX-A in one axilla and placebo in the opposite axilla in a randomized, double-blinded fashion. After one week, there was notable dryness and decrease in malodor in the treated axilla, but persistently odorous secretions in the untreated axilla.

In another study, 19 patients were enrolled and underwent similar interventions with BTX-A. Both odor and axillary sweating in the treated axilla group were significantly lower compared to control. Histological analysis revealed that treated axillas showed atrophic changes and hypoplasia of the apocrine sweat glands.

In 2018, 62 adolescent patients received BTX-A and were reinjected when malodor returned. No local or systemic effects were noted after follow-up of 2.64 years. One injection maintained axillary dryness beyond one month in 38/62 patients and a second dose for up to nine weeks. Another 19 patients received a higher dose with duration extended up to 16 weeks. The authors concluded that BTX-A was a safe and effective long-term therapy.

One study highlighted that poor response to initial therapy did not portend long-term inefficacy. 31 patients were axillary bromhidrosis were recruited with duration of efficacy less than 4 weeks after their first injection. Duration of efficacy increased to 10 weeks after the second injection and 16 weeks after the third.

Malodor recurrence is a possibility after any surgical excision. In 2017, BTX-A was administered in 95 axillae in 53 patients who underwent surgery. Body odor was reduced within
24 hours and had a median duration of effect of 6 months. This suggested that patients with secondary axillary bromhidrosis were more sensitive to BTX-A therapy.\textsuperscript{15}

**Laser Therapy**

Laser therapy offers an alternative to traditional BTX-A therapy. In 2000, 32 female patients with axillary bromhidrosis underwent frequency doubled Q-switched 532nm Nd:YAG laser therapy. Green light is absorbed by melanin which is proximal to apocrine glands thereby causing destruction of the gland. Alteration of the apocrine glands were noted on biopsy. 26 of 32 patients reported good results with resolution of malodor.\textsuperscript{16}

In 2012, 29 patients were treated with pulsed 1,064 nm Nd-YAG laser. Thirteen patients felt well and six fair after the operation. Ten patients relapsed and showed poor results. This higher power laser provided relatively stable radiation but demonstrated difficulty treating severe bromhidrosis in men thought due to their relatively large areas requiring operative treatment. No postoperative hematoma, necrosis, infection, or axillary hair loss occurred.\textsuperscript{17}

In 2013, 18 patients underwent treatment with 1,444 nm Nd:YAG laser with follow-up at six months and confirmation of apocrine gland destruction at six weeks. A 1,444 nm Nd:YAG laser was utilized – a common modality in facial lipoplasty – to target the apocrine glands in the dermal fat layers.\textsuperscript{18} Apocrine gland destruction was confirmed on punch biopsy on postoperative days one and 180. After 6 months, malodor elimination was good in 20 axillae, fair in 12 axillae, and poor in four axillae. 95% of patients reported satisfaction with their results. Long-term efficacy and sustainability of therapy are unknown.\textsuperscript{19}
Microwave Therapy

Microwave therapy utilizes non-ionizing radiation to focus thermal energy upon the dermal-adipose tissue interface and obliterate apocrine and eccrine glands, promote dermal fibrosis, and halt the production of sweat secretions.\textsuperscript{20}

In 2012, 31 adults with primary axillary hyperhidrosis underwent microwave therapy. The primary outcome was sweat production output, but authors also investigated malodor severity. Prior to treatment, 12.9\% (4/31) of patients reported no odor at baseline. At follow-up, this percentage increased to 61.3\% (19/31) at 12-month visit.\textsuperscript{21}

A prospective study in 2015 enrolled seven patients with axillary bromhidrosis. Each patient underwent two treatment sessions and two skin biopsies. Out of seven patients, six met the primary endpoint of odor reduction with a 61.8\% decrease in odor at the 90-day follow-up.\textsuperscript{22} Histological analysis showed a 93\% reduction in the area of apocrine sweat glands.\textsuperscript{22} Another study in 2013 showed 93.8\% reduction in body malodor in 16 axillae with similar histological findings.\textsuperscript{23}

Common adverse events included axillary edema, erythema, discomfort, and paresthesias. Some developed subcutaneous nodules that gradually resolved over a number of weeks. Rare events included brachial plexus injury with median and ulnar nerve neuropathy that partially resolved at a six-month follow-up.\textsuperscript{24, 25}

Surgical Excision

Surgical removal of apocrine glands constitutes the most aggressive form of therapy. Three basic approaches have been described and relate to the approach of subcutaneous tissue and skin removal. Type 1 relates to removal of only subcutaneous tissue; type 2 to removal of
both en bloc; and type 3 to only partial removal of the skin, subcutaneous tissue, and surrounding subcutaneous tissue.\textsuperscript{26}

Overall, procedures tend to yield positive long-term results with a high degree of satisfaction and malodor suppression. However, surgery carries risk of scarring, hematomas, abscess formation, and skin flap necrosis. These complications are related to the need to pull back the wounds and expose the glands risking damaging the skin edge and vascular plexus.\textsuperscript{27}

Since the first surgery for bromhidrosis in 1962\textsuperscript{28}, a variety of approaches have been touted. One involves the creation of two “W” incisions or a small transverse incision. In one study, a total of 20 patients were recruited where 16 showed excellent results. Five patients no longer produced sweat. 28 axillae had markedly reduced sweat, and 32 axillae had reduced hair growth. Transient purpura, minor hematoma, and scarring was noted. Wound infections, dehiscence, flap necrosis, and scar contracture were not present.\textsuperscript{29}

In another technique, 206 patients underwent a subcutaneous gland excision. 95\% of patients were totally satisfied. All patients reported a significant decrease in sweating and 95\% reported axillary hair reduction. Superficial epidermal necrosis occurred in 37\% of axillary vaults but resolved prior to suture removal. Wound dehiscence was the second most common complication, leading to delayed healing; however, all healed within a week.\textsuperscript{30}

Another technique involves excision of the apocrine glands and axillary superficial fascia complex using a single incision. In 63 patients, malodor disappeared in 112 axillae and sweating in 106 axillae. Moderate to significant sweating reduction was observed in 96\% of axillae. There were decreased rates of scar and hematoma formation compared to the “W” incision
technique. A similar study was done with preservation of the axillary fascia showing 111/115 patients were very satisfied with their results.

In 2019, 22 patients underwent gland resection with multiple anchor points and drainage holes. Of the 44 axillae, 42 were cured of bromhidrosis and two were significantly reduced. Perspiration and armpit hair were also reduced. No subcutaneous hematoma was noted. 20 of 22 patients reported no post-operative pain.

Apocrine gland removal via subcutaneous scissors and micropore was done with 34/40 axillae showing excellent results with no notable adverse events. A further study with an elliptical incision showed 56/62 axillae with good to excellent results for malodor elimination. A retrospective study analyzed 396 patients 2 years after treatment with mini-incision with subdermal vascular preservation and showed 87.1% of patients achieving satisfactory results. Of note, odor recurrence was 4.7% and 6.2% at 1 year and 2 years after surgery, respectively. In order to minimize rates of epidermal necrosis, a study involving subcutaneous septa sparing surgery was conducted in 19 patients with no incidence of necrosis and 16/19 patients showing malodor reduction after their first surgery.

A retrospective case series of 50 patients, 40 of which could only be followed up, was performed to minimize the incision in the subdermal excision of apocrine glands. Thirty-five of 40 respondents reported excellent post-operative results with satisfaction rates at 85%. Necrosis of flap margins was frequent, however, noted in 27.3% of patients.

**Liposuction With Suction-Curettage**

As opposed to complete surgical excisions, liposuction with suction-curettage has been studied as an outpatient, minimally invasive procedure. Liposuction was initially reported to be
advantageous due to minimal scar formation and lower level of complications, but early studies highlighted high malodor recurrence rate of 46.9% thought to be due to difficulty visualizing the apocrine glands.\textsuperscript{39}

In a 2006 study, 25 patients with axillary bromhidrosis underwent liposuction via a Fatemi cannula. 49/50 axillae showed good to excellent results. Hair growth decreased in 40 axillae and perspiration in 42 axillae. Postoperative scarring was considered an acceptable outcome and seen in 34 of 50 axillae. Histological examination of 14 patients postoperatively showed a decrease in apocrine and eccrine glands.\textsuperscript{40}

Another study in 2008 examined the efficacy of suction-curettage with combination use of the Fatemi and Cassio cannula in 65 patients. With 10 months of followup, overall subjective assessment was reported as excellent in 47 patients with 84.6% of patients fully satisfied with the procedure.\textsuperscript{41}

A further technique was employed combining suction-curettage with subdermal undermining. 87.5% of axillae showed significant malodor eradication with combination therapy compared to the 33% of axillae associated with suction-curettage alone.\textsuperscript{42} In 2017, 228 patients were followed up after treatment with liposuction with micro-incisions. Malodor was eliminated in 141/157 axillae.\textsuperscript{43} Another study used liposuction with trimming in 158 patients and 294 showing good to excellent malodor elimination.\textsuperscript{44}

A meta-analysis was performed containing 10 studies with a total of 1,124 participants comparing the curative effect of liposuction curettage to laser treatment and open excision. No statistical difference was found in recurrence, complete response, or overall response. Lower incidence of complications were noted in the liposuction group.\textsuperscript{45}
Discussion

Bromhidrosis is a condition of noxious body odor. A variety of treatment modalities have been developed. The level of intervention is dependent upon a multitude of factors including severity of the condition, patient preference, toleration of side-effects, and willingness for repeat treatments.

For patients with bromhidrosis refractory to comprehensive hygienic routines, a reasonable approach involves ruling out all concomitant medical illnesses such as diabetes or hyperthyroidism. If this search has returned negative, the next option can depend on patient preference, cost, or other factors.

BTX-A appears to show consistent benefit across multiple studies, but effects appear to be short-term, thereby necessitating episodic treatments. This can impose a prohibitive financial barrier. If BTX-A proves ineffective or financially unfeasible, more aggressive options include laser therapy, microwave therapy, or surgical therapy.

Microwave therapy appears to have good remission rates. However, efficacy was tested predominantly in patients with axillary hyperhidrosis – which can contribute to bromhidrosis – but not specifically in those with bromhidrosis. Additionally, the procedure incurs high front-end costs with unknown long-term suppression of body odor. Given it is non-invasive, safe, carries high levels of patient satisfaction, microwave therapy may treat bromhidrosis, but future studies involving larger cohorts with bromhidrosis are needed.

Laser therapy is a promising modality with good patient satisfaction and biopsy-proven destruction of apocrine glands. The 1,444 nm Nd:YAG laser modality showed considerable benefit at six months with good reported satisfaction and fewer incidents of hematoma and
wound infection. However, laser therapy is invasive requiring small incisions. Complications of pain, short-term decreased mobility, and superficial epidermal necrosis have been reported. Despite this, complications were not as evident or severe as compared to surgical intervention. A larger cohort is needed to investigate efficacy and ideal laser configuration.

Surgery remains the most aggressive and possibly efficacious option, but it runs the risk of the greatest number of complications. Rates of malodor recurrence are lowest in surgery, yet the ideal surgical modality is uncertain. If recurrence of malodor occurs following surgery, it may be reasonable to provide BTX-A therapy as opposed to another surgical intervention.

In conclusion, treatment efforts should be made towards hygiene education. If disease is mild, it is acceptable to begin with BTX-A therapy given its efficacy and non-invasive nature. If malodor is moderately distressing, BTX-A therapy cost prohibitive, or if patients desire more permanent suppression, then laser or microwave therapy should be entertained. Although the data on microwave therapy is promising, laser therapy is better studied and should be recommended as step-up therapy. Lastly, if bromhidrosis is severe, surgical intervention should be offered as this affords the best chance for permanent cure albeit with the highest risks of adverse events.
Table 1: Botulinum Toxin-A Studies

<table>
<thead>
<tr>
<th>Question</th>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficacy and Histological Changes of BTX-A</td>
<td>Wu [12]</td>
<td>Prospective, randomized, double-blind, side-by-side comparison study</td>
<td>19</td>
<td>3 Months</td>
<td>Malodor and sweat production decreased; apocrine atrophy and hypoplasia</td>
<td>Nil.</td>
</tr>
<tr>
<td>Safety and Efficacy of BTX-A in Adolescents</td>
<td>Wang [13]</td>
<td>Prospective Cohort</td>
<td>62</td>
<td>2.64 years</td>
<td>38/62 axilla dry at 4 weeks, length of suppression increased with further doses.</td>
<td>Nil.</td>
</tr>
<tr>
<td>Efficacy of BTX-A in Initial Non-Responders</td>
<td>He [14]</td>
<td>Prospective Cohort</td>
<td>31</td>
<td>26 weeks</td>
<td>Durate of efficacy rose to 10 weeks after 2nd dose, 16 weeks after 3rd dose</td>
<td>Nil</td>
</tr>
<tr>
<td>Efficacy of BTX-A in secondary bromhidrosis</td>
<td>He [15]</td>
<td>Prospective Cohort</td>
<td>53</td>
<td>Variable. Follow-up ended when malodor returned to baseline.</td>
<td>Reduced odor at 24 hours. At 6 months, 33/53 patients with no malodor recurrence. Median duration: 6 months</td>
<td>Nil.</td>
</tr>
</tbody>
</table>

Table 2: Laser Therapy Studies

<table>
<thead>
<tr>
<th>Question</th>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficacy of frequency-doubled Q-switched 523 nm Nd:YAG</td>
<td>Kunachak [16]</td>
<td>Prospective Cohort</td>
<td>32</td>
<td>6-18 Months</td>
<td>26 patients showed good to excellent results, 4 fair results, and 2</td>
<td>Hyperpigmentation.</td>
</tr>
</tbody>
</table>
### Efficacy of frequency-doubled Q-switched 1,064 nm Nd:YAG Laser

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim [17]</td>
<td>Prospective Cohort</td>
<td>29</td>
<td>12.8 Months</td>
<td>19 patients with fair-to-good results, ten patients poor results.</td>
<td>2nd degree burns.</td>
</tr>
</tbody>
</table>

### Efficacy of frequency-doubled Q-switched 1,444 nm Nd:YAG Laser

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jung [19]</td>
<td>Prospective Cohort</td>
<td>18</td>
<td>6 months</td>
<td>Malodor elimination good in 20 axillae, fair in 12, poor in four.</td>
<td>Post-Op Pain for 1 week, superficial epidermal necrosis.</td>
</tr>
</tbody>
</table>

### Table 3: Microwave Therapy Table

<table>
<thead>
<tr>
<th>Question</th>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficacy of microwave therapy on axillary hyperhidrosis and body malodor</td>
<td>Hong [21]</td>
<td>Prospective Cohort</td>
<td>31</td>
<td>6 Months</td>
<td>4/31 patients reported no odor at onset, increased to 19/31 at 12 months.</td>
<td>Axillary edema</td>
</tr>
<tr>
<td>Efficacy of microwave therapy on axillary bromhidrosis</td>
<td>Chang [22]</td>
<td>Prospective Cohort</td>
<td>7</td>
<td>3 Months</td>
<td>61.8% reduction in odor at the 90-day follow-up.</td>
<td>Axillary edema</td>
</tr>
<tr>
<td>Efficacy of microwave therapy on bromhidrosis</td>
<td>Lee [23]</td>
<td>Prospective Cohort</td>
<td>11</td>
<td>7 months</td>
<td>93.8% (15/16 axillae) showed good to excellent results.</td>
<td>Axillary edema, erythema, discomfort, paresthesia, subcutaneous nodules.</td>
</tr>
</tbody>
</table>
Table 4: Surgical Intervention Table

<table>
<thead>
<tr>
<th>Question</th>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficacy of “Double W” incision approach with tumescent technique</td>
<td>Li [29]</td>
<td>Prospective Cohort</td>
<td>20</td>
<td>Average of 6 Months</td>
<td>32/40 Axillary showed excellent results, 8 good results. Malodor significantly decreased. Overall Satisfaction: 97.5%.</td>
<td>Transient purpura, minor hematoma, scarring.</td>
</tr>
<tr>
<td>Efficacy of subdermal excision of apocrine glands</td>
<td>Qian [30]</td>
<td>Prospective Cohort</td>
<td>206</td>
<td>18.1 Months</td>
<td>398/412 Axillae showed good malodor elimination. 95% satisfaction.</td>
<td>Superficial epidermal necrosis, wound dehiscence, hematoma, seroma, folding of skin flap, pressure blister, wound infection</td>
</tr>
<tr>
<td>Efficacy of excision of apocrine glands—axillary superficial fascia as a single entity</td>
<td>He [31]</td>
<td>Prospective Cohort</td>
<td>63</td>
<td>Average of 13 months</td>
<td>112/126 axillae with significant odor eradication. 88.9% satisfaction.</td>
<td>Skin edge necrosis, upper limb edema.</td>
</tr>
<tr>
<td>Efficacy of apocrine gland excision with preservation of fascia</td>
<td>Li [32]</td>
<td>Prospective Cohort</td>
<td>115</td>
<td>Average of 6 months</td>
<td>112/115 malodor disappearance and 3/115 considerable reduction. 96.5% satisfaction.</td>
<td>Hematoma, blisters, delayed wound healing, scars,</td>
</tr>
<tr>
<td>Efficacy of excision of apocrine glands with anchor points and drainage holes</td>
<td>Wang [33]</td>
<td>Prospective Cohort</td>
<td>22</td>
<td>Average of 6 months</td>
<td>42/44 axillae completely cured, 2/44 significantly reduced. 95.5% complete satisfaction</td>
<td>Slight epidermal necrosis</td>
</tr>
<tr>
<td>Efficacy of subcutaneous scissor with micropore.</td>
<td>Dai [34]</td>
<td>Prospective Cohort</td>
<td>20</td>
<td>Average of 6 months</td>
<td>34/40 axillae showed excellent results, 6/40 good results of malodor elimination. 97.5% satisfaction.</td>
<td>Moderate pain (2/20 patients) after surgery.</td>
</tr>
<tr>
<td>Efficacy of elliptical incision</td>
<td>Van [35]</td>
<td>Prospective Cohort</td>
<td>31</td>
<td>6 months</td>
<td>56/62 axillae showed good to excellent results for malodor elimination.</td>
<td>Skin necrosis, hematoma.</td>
</tr>
<tr>
<td>Efficacy of Mini-</td>
<td>Zhao [36]</td>
<td>Retrospective</td>
<td>396</td>
<td>2 year period of</td>
<td>87.1% of patients</td>
<td>Hematoma,</td>
</tr>
</tbody>
</table>
Incision with subdermal vascular preservation showed satisfactory results. relapsing comedones, epidermoid cysts, keloids, scar, odor recurrence.

Efficacy of subcutaneous septa sparing surgery Hsu [37] Prospective Cohort 19 3 months 16/19 patients developed malodor reduction after 1\textsuperscript{st} surgery. Ecchymosis, revision surgery.

Efficacy of “Pinch and Turn-Over Technique” Lee [38] Retrospective Case Series 40 Average of 30.3 months. 35/40 patients had excellent or good results. Skin necrosis, hematoma,

<table>
<thead>
<tr>
<th>Question</th>
<th>Authors</th>
<th>Study Design</th>
<th>Number Of Patients</th>
<th>Follow-Up</th>
<th>Response Rates</th>
<th>Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficacy of Liposuction with Fatemi cannula</td>
<td>Lee [40]</td>
<td>Prospective Cohort</td>
<td>25</td>
<td>10.7 Months</td>
<td>38/50 axillae graded as excellent.</td>
<td>Ecchymosis.</td>
</tr>
<tr>
<td>Efficacy of Liposuction with Fatemi and Cassio Cannula</td>
<td>Kim [41]</td>
<td>Prospective Cohort</td>
<td>65</td>
<td>10 months</td>
<td>60/65 patients had excellent to fair results</td>
<td>Recurrence, skin sloughing, seroma, wound dehiscence.</td>
</tr>
<tr>
<td>Efficacy of suction-curettage with subdermal undermining</td>
<td>He [42]</td>
<td>Prospective Cohort</td>
<td>80</td>
<td></td>
<td>140/160 axillae showed significant malodor eradication</td>
<td>Hematoma, skin necrosis, epidermal cyst,</td>
</tr>
<tr>
<td>Efficacy of liposuction-curettage through mini-incisions</td>
<td>Yang [43]</td>
<td>Prospective Cohort</td>
<td>228</td>
<td>15 months</td>
<td>141/157 axillae showed excellent elimination of malodor. 94.9% patient satisfaction.</td>
<td>Skin Necrosis, local epidermal damage.</td>
</tr>
<tr>
<td>Efficacy of subcutaneous curettage with trimming</td>
<td>Wang [44]</td>
<td>Prospective Cohort</td>
<td>158</td>
<td>6-18 months</td>
<td>294/316 axillae showed excellent to good malodor elimination. 97.3% satisfaction.</td>
<td>Hematoma, scars.</td>
</tr>
</tbody>
</table>
References


3. Martin, A., Saathoff, M., Kuhn, F. et al. A functional ABCC11 allele is essentia in the

4. Sato K, Leidal R, Sato F. Morphology and development of an apoeccrine sweat gland in
doi:10.1152/ajpregu.1987.252.1.R166

5. Lam Hoai XL, Kabagabo C, Simonart T. Treatment of axillary bromhidrosis with

treated with aluminium chloride in a salicylic acid gel base. Int. J. Dermatol. 37, 701–703

7. Helou J, Haber R, Kechichian E, Tomb R. A case of generalized bromhidrosis following

8. Kim, T.N., Feng, Q.L., Kim, J.O. et al. Antimicrobial effects of metal ions (Ag+, Cu2+,


