Does the Addition of Progressive Tension Sutures to Drains Reduce Seroma Incidence After Abdominoplasty? A Systematic Review and Meta-Analysis

Samer Jabbour, MD; Cyril Awaida, MD; Rachad Mhawej, MD; Samer Bassilios Habre, MD; and Marwan Nasr, MD

Abstract

Background: Progressive tension sutures (PTS) are commonly utilized to reduce postoperative seroma in abdominoplasty. However, current evidence regarding PTS in abdominoplasty is limited to small series and the findings of single institutions.

Objectives: The authors reviewed the available literature concerning the effects of PTS and drains on seroma formation following abdominoplasty, and summarized the different techniques that have been described to date.

Methods: We conducted a systematic review of the Medline, Embase, and Cochrane databases. We identified randomized controlled trials (RCTs) and observational studies in which the numbers of patients who had postoperative seroma were indicated. We applied the Cochrane Collaboration’s tool for assessing the risk of bias.

Results: Seven studies were included (three RCTs and four retrospective studies). Patients who had PTS and drains following abdominoplasty had a significantly lower rate of postoperative seroma than those who had drains only. The mean surgical time difference between the two groups was 23 minutes. There was no difference in postoperative seroma rate in patients who had PTS and drains placed following abdominoplasty compared to those who had PTS only.

Conclusions: Addition of PTS to drains reduces the risk of postoperative seroma in standard abdominoplasty. More RCTs with larger sample sizes and better comparability are warranted to confirm with more confidence the impact of PTS in abdominoplasty.

Level of Evidence: 2

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Following the dramatic increase in the prevalence of obesity and bariatric surgeries, abdominoplasty has become one of the most commonly performed surgical procedures for body contouring. Nevertheless, abdominoplasty is not free of complications with reported overall complication rate ranging from 4% to 80%. Seroma is the most common early complication after abdominoplasty. Its incidence is widely variable, but 10% is the value accepted by most authors. Seroma is defined as a collection of fluid within a localized space. It is a known complication of operations involving large cutaneous flaps elevation. Several hypotheses have been proposed to explain seroma formation, including intraoperative trauma, hematoma, fluid accumulation, and inadequate drainage. The addition of progressive tension sutures (PTS) to the surgical technique is a well-recognized method to reduce seroma formation. However, the current evidence regarding PTS in abdominoplasty is limited to small series and the findings of single institutions. The objective of this systematic review is to summarize the different techniques that have been described to date and evaluate their impact on seroma formation following abdominoplasty.

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proposed to explain the etiology of seroma formation after abdominoplasty. The most accepted one is that flap harvest with concomitant shearing leads to the development of a dead space, and subsequent inflammation increases vascular and lymphatic permeability, resulting in fluid collection. Risk factors for seroma development include high BMI, important weight loss, extensive dissection, previous supraumbilical scars, and concomitant liposuction. Smoking is also associated with a higher risk of seroma formation even after 45 days of abstinence. Despite being often self-limited, seromas can sometimes result in deleterious effects. By increasing the pressure under the abdominal flap it causes wound dehiscence, flap necrosis, spontaneous drainage through the surgical wound, and infections. Seroma management is cumbersome, it may require multiple needle aspirations, potential drain replacements, and revision surgeries. All of the latter increase morbidity, cost, and patient discomfort. If left untreated, seroma may result in formation of a fibrous pseudobursa leading to asymmetry and poor esthetic outcome. A number of preventive measures have been recommended to decrease the rates of postoperative seroma: placement of drains, atraumatic handling of the skin flap, the application of compression garments, the delivery of tissue adhesives, and the placement of progressive tension sutures (PTS). PTS consists of placing sutures at periodic intervals between the abdominal flap and fascia. It was first briefly introduced by Mladick. Baroudi and Ferreira described it more extensively as ‘quilting sutures’ to reduce dead space and shearing forces. The term ‘progressive tension suture’ was popularized by Pollock and Pollock because this technique allows tension-free closure of the abdominal flap by the distribution of tension on each suture with advancement of the flap in a proximal to distal direction. Different technical variations exist for the use of PTS. Some authors prefer separate stitches while other use running sutures. Both absorbable and non-absorbable sutures have been utilized. Use of PTS as a substitute for suction drains was described by some surgeons while others associate both techniques to further reduce seroma formation. The existing literature regarding PTS in abdominoplasty is limited to small retrospective studies and few prospective ones. To our knowledge, no systematic review of these studies has been published to date. In the present review and meta-analysis, we evaluated the efficacy of PTS and drains in preventing seroma formation following abdominoplasty.

**METHODS**

The primary endpoint of this review was to study the effect of PTS and drains on seroma formation following abdominoplasty. Secondary analysis was conducted to determine the effect of PTS placement on surgical time. The operative and postoperative details including abdominal flap elevation method, PTS type and technique of application, postoperative compression and suction drain placement, seroma evaluation methods, puncture frequency, days of drains in situ, and length of hospital stay were also evaluated.

**Study Selection**

On December 10, 2015, we conducted a search of published articles in Medline, Embase, and Cochrane databases. The search was done with no restrictions and with specific terms for abdominoplasty combined with terms for PTS (Appendix A, available as Supplementary Material at www.aestheticsurgeryjournal.com). All English, German, or French studies published before the search date were evaluated. After excluding duplicates, the two first authors (S.F.J. and C.J.A.) screened the titles and abstracts of all the articles. Studies evaluating the effect of PTS on seroma formation following abdominoplasty were considered candidate studies and the full text of each of these articles was accessed for further evaluation. The reference list of each study was manually screened for additional pertinent articles. Candidate studies that were not available online were obtained by contacting the authors by email.

As the outcomes can vary widely according to surgery type, surgical techniques, and patient characteristics, only two-arm studies with a control group were considered for inclusion.

To be included in the meta-analysis a study had to belong to one of either categories of comparison: Studies comparing seroma rates in patients who had both PTS and drains vs control patients where only drains were used, and studies comparing seroma rates in patients who had both PTS and drains vs control patients where only PTS were used. Excluded from the meta-analysis were single arm studies with no control group, studies with extensive liposuction of the abdominal flap, and studies that involved concomitant interventions, such as tissue adhesives, to prevent seroma formation. Disagreements were resolved by discussion and all authors unanimously agreed on the final selection. The methodological quality of the included studies was assessed using the Cochrane Collaboration’s tool for assessing the risk of bias. The quality of this systematic review and meta-analysis was assessed using the AMSTAR checklist, which is available as Supplementary Material at www.aestheticsurgeryjournal.com.

**Data Collection**

Data from each study were extracted into a form with the following parameters: primary author, publication year, study design, number of patients, mean age, gender, mean body mass index (BMI), smoking status, number of seroma cases, puncture frequency, duration of drains in situ, mean hospital stay, surgical time, flap elevation method, PTS
type, and application technique, postoperative compression and drains usage and seroma evaluation methods.

Data Synthesis

Review Manager software (RevMan, version 5.3, Copenhagen, Denmark) was utilized to compute the pooled effect estimate with a random-effects model for either binary or continuous outcomes when there were more than two studies included. When two or fewer studies were included, the fixed effects model was utilized. For dichotomous outcomes, the Mantel-Haenszel (M-H) method was applied to calculate the relative risk (RR) and corresponding 95% confidence interval (CI). For continuous outcomes, the inverse-variance weighting was applied to calculate the mean difference and corresponding 95% CI. The data abstracted from the individual studies were pooled in order to determine effect estimate. The weights of those results were determined by the variance of each trial estimate.

RESULTS

The initial search of the databases yielded 89 citations, 26 of which were duplicates. Of the 63 unique studies, 46 were selected as candidates based on assessments of titles and abstracts. Following full-text review, 3 RCT and 4 retrospective studies with a total of 808 patients were selected for inclusion in the meta-analysis (Table 1). The stepwise approach for study selection is summarized in Figure 1. Reported outcomes including postoperative seroma rates, surgical time, the need for postoperative seroma puncture, days of drains in situ, and length of hospital stay are summarized in Tables 2 and 3. The puncture frequency of postoperative seroma was reported in 4 studies, only one showed that PTS reduces the need for puncture and aspiration. PTS with each row having between 2 and 4 symmetrically placed sutures. The proposed mechanisms of action of PTS in reducing seroma formation and drainage are the elimination of dead space rather than concentration of tension along the incision, and the reduction in shear forces by mechanical fixation of tissue. The flap elevation method, the type of PTS used, the technique of PTS application, the usage of postoperative drainage and compression and the seroma evaluation method are summarized in Table 4.

Meta-Analysis

Of the included studies, 6 compared seroma rates in patients who had PTS and drains vs control patients where only drains were used and 2 studies compared seroma rates in patients who had PTS and drains vs control patients where only PTS were used. Owing to the heterogeneity, the two groups of studies were investigated separately in the following analysis.

Primary Endpoint: Seroma Incidence

PTS and drains vs drains only

Six studies comparing the effect of PTS and drains (PTS + D) vs drains only were analyzed; 391 patients had PTS and drains while 342 patients served as the control group with drains only (Table 2).

A moderate level of heterogeneity was observed in the 6 studies with respect to the incidence of seroma (I^2 = 56%). The results of the random-effects model indicated a significantly lower postoperative seroma rate in the PTS + D group vs the control group (RR, 0.28; 95% CI, 0.09-0.82; P = .02; Figure 2).

PTS and drains vs PTS only

Two studies comparing the effect of PTS + D vs PTS only were analyzed; 47 patients had PTS and drains while 43 patients served as the control group with PTS only (Table 3).

No heterogeneity was observed in the 2 studies with respect to the incidence of seroma (I^2 = 0%). The

Table 1. Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>No. of Patients</th>
<th>Mean Age (years)</th>
<th>Female Patients (%)</th>
<th>Mean BMI (kg/m^2)</th>
<th>Smokers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>PTS + D</td>
<td>D</td>
<td>PTS + D</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>40.1</td>
<td>39.7</td>
</tr>
<tr>
<td>Andrades et al</td>
<td>RCT</td>
<td>R</td>
<td>15</td>
<td>32</td>
<td>28</td>
<td>NR</td>
</tr>
<tr>
<td>Arantes et al</td>
<td>R</td>
<td>21</td>
<td>17</td>
<td>34.8</td>
<td>34.7</td>
<td>NR</td>
</tr>
<tr>
<td>Di Martino et al</td>
<td>RCT</td>
<td>96</td>
<td>50</td>
<td>39.5</td>
<td>37</td>
<td>NR</td>
</tr>
<tr>
<td>Khan U</td>
<td>R</td>
<td>54</td>
<td>49</td>
<td>42.4</td>
<td>37.7</td>
<td>98.1</td>
</tr>
<tr>
<td>Margara et al</td>
<td>RCT</td>
<td>56</td>
<td>34</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Sforza et al</td>
<td>R</td>
<td>100</td>
<td>226</td>
<td>41.2</td>
<td>40.2</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>342</td>
<td>423</td>
<td>43</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D, drains; NR, not reported; PTS, progressive tension sutures; R, retrospective; RCT, randomized controlled trial.
results of the fixed-effects model indicated no difference in postoperative seroma rates between the PTS + D group and the control group (RR, 1.23; 95% CI, 0.44-3.44; \( P = .69 \); Figure 3).

**Secondary Endpoint: Surgical Time**

Substantial heterogeneity was observed among the 3 studies with respect to the surgical time (I\(^2\) = 91%) (36,44,46). The mean surgical time difference between the

PTS + D group and the drains only group was 23.19 mn (95% CI, −2.34-48.72; \( P = .07 \); Figure 4).

The results of the meta-analysis and assessments of risk are summarized in Appendices B and C, which are available as Supplementary Material at www.aestheticsurgeryjournal.com.

**DISCUSSION**

The proposed mechanisms of action of PTS in reducing postoperative seroma rates are the elimination of dead space, the distribution of tension along the entire skin flap surface rather than concentration of tension along the incision, and the reduction in shear forces by mechanical fixation.\(^{10,44}\)

According to this meta-analysis, the addition of PTS to drains during wound closure reduces the incidence of seroma following abdominoplasty. These results are consistent with published literature relating to seroma formation after flap harvest in other anatomical sites such as latissimus dorsi,\(^{12,47,48}\) facelift,\(^{49}\) and mastectomy.\(^{50,51}\) Although numerous techniques were used to apply PTS, all authors followed the principle described by Pollock and Pollock which consists of progressively advancing the abdominal flap from proximal to distal while applying adhesion sutures.\(^{38}\) Andrades et al applied separate sutures in the midline at intervals of 1 cm and added lateral sutures as needed.\(^{36}\) Arantes et al placed the sutures along the midline and equidistant from this line on both sides with 4 cm between the stiches.\(^{45}\) Di Martino et al placed the sutures symmetrically to the linea alba, 3 cm apart.\(^{24}\) Khan et al applied sutures only along the midline at intervals of approximately 1 cm.\(^{44}\) Khan used 3 to 4 horizontal rows of PTS with each row having between 2 and 4 symmetrically placed sutures.\(^{43}\) Margara et al repositioned the umbilicus using the high superior tension technique described by Le

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**Table 2. Drains Alone Group Vs Progressive Tension Sutures and Drains Group**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Procedures</th>
<th>No. of Seroma (%)</th>
<th>Puncture Frequency</th>
<th>Days of Drains In Situ</th>
<th>Surgical Time (mn)</th>
<th>Mean Length of Hospital Stay (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D</td>
<td>PTS + D</td>
<td>D</td>
<td>PTS + D</td>
<td>D</td>
<td>PTS + D</td>
</tr>
<tr>
<td>Andrades et al(^{36})</td>
<td>15</td>
<td>15</td>
<td>5 (33)</td>
<td>4 (27)</td>
<td>2 (0-4)</td>
<td>1 (0-4)</td>
</tr>
<tr>
<td>Di Martino et al(^{24})</td>
<td>21</td>
<td>17</td>
<td>5 (23.8)</td>
<td>0 (0)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Khan U(^{43})</td>
<td>96</td>
<td>50</td>
<td>24</td>
<td>2</td>
<td>2.37 (1-5)</td>
<td>0</td>
</tr>
<tr>
<td>Khan S(^{44})</td>
<td>54</td>
<td>49</td>
<td>10 (18.5)</td>
<td>3 (6.1)</td>
<td>3</td>
<td>3.33</td>
</tr>
<tr>
<td>Margara et al(^{45})</td>
<td>56</td>
<td>34</td>
<td>1 (1.8)</td>
<td>1 (2.9)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Sforza et al(^{22})</td>
<td>100</td>
<td>226</td>
<td>12 (12)</td>
<td>0 (0)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>342</td>
<td>391</td>
<td>57 (16.7)</td>
<td>10 (2.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D, drains; NR, not reported; PTS, progressive tension sutures; Sys, systematic measure for all patients.
Table 3. Progressive Tension Sutures and Drains Group Vs Progressive Tension Sutures Alone Group

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Procedures</th>
<th>No. of Seroma (%)</th>
<th>Puncture Frequency</th>
<th>Mean Length of Hospital Stay (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PTS + D</td>
<td>PTS + D</td>
<td>PTS</td>
<td>PTS + D</td>
</tr>
<tr>
<td>Andrades et al&lt;sup&gt;25&lt;/sup&gt;</td>
<td>15</td>
<td>4 (27)</td>
<td>5 (33)</td>
<td>1 (0-4)</td>
</tr>
<tr>
<td>Arantes et al&lt;sup&gt;45&lt;/sup&gt;</td>
<td>32</td>
<td>1 (3.12)</td>
<td>1 (3.5)</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>5 (10.6)</td>
<td>6 (14)</td>
<td></td>
</tr>
</tbody>
</table>

D, drains; NR, not reported; PTS, progressive tension sutures; Sys, systematic measure for all patients.

Table 4. Procedure and Postoperative Details of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Flap Elevation Method</th>
<th>Type of Quilting Sutures</th>
<th>Technique of Application</th>
<th>Postoperative Compression and Drains</th>
<th>Seroma Evaluation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrades et al&lt;sup&gt;25&lt;/sup&gt;</td>
<td>Electrocautery</td>
<td>Absorbable sutures</td>
<td>30-40 separate sutures as described by Pollock and Pollock&lt;sup&gt;21&lt;/sup&gt;</td>
<td>2 drains + elastic garments for 3-4 weeks</td>
<td>Clinical&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arantes et al&lt;sup&gt;45&lt;/sup&gt;</td>
<td>NR</td>
<td>Vicryl 2-0</td>
<td>Separate sutures along the midline and on either side of the abdomen, with a distance of approximately 4 cm between the stitches</td>
<td>Drains removed when &lt;30 mL/24 h</td>
<td>Clinical</td>
</tr>
<tr>
<td>Di Martino et al&lt;sup&gt;24&lt;/sup&gt;</td>
<td>Electrocautery</td>
<td>Nylon 2-0</td>
<td>Separate sutures placed symmetrically to the linea alba 3 cm apart</td>
<td>Two 3.2 mm drains removed when &lt;40 mL/24 h + elastic garments for 4 weeks</td>
<td>Clinical&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Khan U&lt;sup&gt;43&lt;/sup&gt;</td>
<td>Electrocautery</td>
<td>Vicryl 2-0</td>
<td>Separate sutures in 3-4 horizontal rows with each row having a minimum of 2 and a maximum of 4 sutures</td>
<td>Elastic garments for 4 weeks</td>
<td>Clinical</td>
</tr>
<tr>
<td>Khan S&lt;sup&gt;44&lt;/sup&gt;</td>
<td>Electrocautery</td>
<td>Vicryl 0</td>
<td>Separate sutures along the midline with 1 cm between the stitches</td>
<td>1 drain removed when &lt;30 mL/24 h for 2 days</td>
<td>Clinical</td>
</tr>
<tr>
<td>Margara et al&lt;sup&gt;46&lt;/sup&gt;</td>
<td>Electrocautery</td>
<td>Vicryl 2-0</td>
<td>Separate sutures along the midline with 1 cm between the stitches + fewer stitches in lateral areas</td>
<td>Drains removed when &lt;30 mL/24 h + elastic garments for 4 weeks</td>
<td>Clinical</td>
</tr>
<tr>
<td>Sforza et al&lt;sup&gt;22&lt;/sup&gt;</td>
<td>NR</td>
<td>Monocryl 2-0</td>
<td>9 to 15 separate sutures with at least 5 cm between the stitches</td>
<td>Two size 14 drains + compression garments for 6 weeks</td>
<td>Clinical</td>
</tr>
</tbody>
</table>

NR, not reported. *These studies performed both Ultrasound and clinical evaluations, but only clinical results were included in our review.

Figure 2. Forest plot summarizing the incidences of postoperative seroma in patients who received PTS and drains following abdominoplasty (PTS + D group) vs patients who received drains only (D group), as determined in the present meta-analysis. M-H, Mantel-Haenszel method.
Louarn and Pascal and additional PTS were then added in the midline at intervals of 1 cm with fewer sutures in the lateral area. Sforza et al applied 9 to 15 sutures distributed equally with at least 5 cm between each suture.

The results of the meta-analysis comparing the placement of PTS + D with PTS only were noteworthy. In fact, the combination of PTS and drains did not show additional protective effect on seroma formation when compared to PTS alone. Therefore, when PTS are used drain placement may become unnecessary. However, more studies are needed to ascertain this conclusion.

Presumed disadvantages of PTS include difficult placement, increase in surgical time, and creation of visible dimplings. The meta-analysis showed that PTS placement increased the surgical time by a mean of 23 minutes.

Although better designed and more powerful studies are required to obtain a higher level of evidence on the benefits of PTS, the application of these sutures can be recommended to reduce postoperative seroma rates in abdominoplasty.

Despite a comprehensive review of the literature, this meta-analysis presents some inherent limitations. These limitations are associated with the variability of the studies included in our meta-analysis. To reduce this variability, when both clinical and ultrasound evaluation for postoperative seroma were reported, only clinical evaluation was...
used as it was common to all included studies (Table 4). Also, only studies performing a standard abdominoplasty were included in this review. Furthermore, due to the lack of RCTs on the subject, four retrospective studies were included. These studies had a non-randomized design; therefore, the potential variables that could be associated with the outcome could not be fully controlled, which may have reduced the strength of this review. The Sforza paper is by far the largest series in the PTS + D vs drains-only meta-analysis, yet it is a retrospective study. The sensitivity analysis where the retrospective study Sforza et al was removed did not alter the results of the meta-analysis, and therefore the study did not significantly impact the final interpretation of the results. On the other hand, removing the study did reduce the heterogeneity from an $I^2 = 56\%$ to an $I^2 = 28\%$ (Figure 5). In the literature the majority of the two arm studies with a control group compared PTS + drains vs drains placement alone. We did not find enough studies that compared PTS alone to drains alone to include them in this meta-analysis. It is still premature to do such a comparison. It should however be done when enough controlled studies are available. Another limitation of this study is the low number of patients. More large scale well designed studies are needed to address these limitations.

CONCLUSIONS

Based on the result of this review, addition of PTS to drains reduces the risk of postoperative seroma in standard abdominoplasty. However, there is some clinical and methodological heterogeneity among studies addressing the effects of PTS in abdominoplasty. Despite its limitations, the present meta-analysis may act as a guide for clinical decision making. Further RCT involving larger sample sizes and better comparability of interventions are warranted to assess with confidence the impact of PTS in abdominoplasty.

Supplementary Material

This article contains supplementary material located online at www.aestheticsurgeryjournal.com.

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