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REVIEW BODY CONTOURING

The Global Prevalence of Seroma After Abdominoplasty: A Systematic Review and Meta-Analysis

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Abstract

Background Abdominoplasty is one of the most common cosmetic surgeries performed worldwide. Seroma is also the most common local complication associated with abdominoplasty, which increases care costs, reduces patient satisfaction, and has serious complications for patients. Results of previous studies report different levels of seroma prevalence after abdominoplasty. The aim of this study is to standardize the statistics of the prevalence of seroma after abdominoplasty using meta-analysis.

Methods In this systematic review and meta-analysis study, data from studies conducted on the global prevalence of seroma after abdominoplasty was extracted using the keywords "Prevalence, Epidemiology, Complications, Abdominoplasty, Seroma, and Lipo abdominoplasty" in the databases of Science, Scientific Information Database, MagIran, Embase, Scopus, PubMed, Web of Science, and Google Scholar search engine without time limit until October 2020. The random-effects model was used to analyze the eligible studies, and the heterogeneity of the studies was investigated with the I^2 index. Data analysis was performed using Comprehensive Meta-Analysis software (Version 2).

Results In reviewing 143 studies (five studies related to Asia, 55 studies related to Europe, three studies related to Africa, and 80 studies related to the Americas) with a total sample size of 27834 individuals, the global prevalence of seroma after abdominoplasty was obtained as 10.9% (95% CI: 9.3-3.6.6%) and the highest prevalence of seroma was related to the Europe continent with 12.8% (95% CI: 10.15-3.9%). The results from meta-regression showed a declining trend in the global prevalence of seroma after abdominoplasty with an increase in the sample size, age of study participants, and the year of study ($p < 0.05$).

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Conclusions This study shows that the prevalence of seroma after abdominoplasty is high globally. Therefore, physicians and specialists must consider its importance and take the controlling and treatment measures seriously.
Level of Evidence III 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 Table of Contents or online Instructions to Authors www.springer.com/00266.

Keywords Seroma · Abdominoplasty · Systematic review · Meta-analysis

Abbreviations

SID	Scientific information database
WoS	Web of science
STROBE	Strengthening the reporting of observational studies in epidemiology
PRISMA	Preferred reporting items for systematic reviews and meta-analysis

Background

Abdominoplasty is one of the most common cosmetic surgeries performed worldwide [1]. The purpose of this surgery is to restore the natural anatomical structure of the lower abdominal skin and address abdominal contour abnormalities. Abdominoplasty involves removing extra fat and skin from the middle and lower abdomen and tightening muscles and fascia of the abdominal wall [2]. Patients with evident skin and loose muscular-aponeurotic layer, with or without hernia or extra abdominal fat, are considered good candidates for abdominal plastic surgery [3]. Although men are increasingly undergoing this type of surgery, it is mainly performed on women [4], especially for women who have lost a significant amount of weight or have experienced multiple pregnancies [5]. Severe weight loss leads to extra skin that in turn damages the patient's quality of life. Loose and sagging skin causes frequent recurrence, integrated fungal infections, abscesses, malodor, and pain or physical discomfort, and disrupts physical activity. Body contouring surgery seeks to remove these problems and improve the patient's quality of life and increase the patient's body image and physical and mental well-being [6–9].

It is estimated that more than 800,000 people in the world undergo this operation every year [1]. Abdominoplasty is one of the best cosmetic surgeries, which was recognized as the fourth most popular technique worldwide in 2012 [10] and was ranked as the fourth most popular in 2018 (888712 operations) [11, 12]. As reported by the American Society of Plastic Surgeons (ASPS), abdominoplasty was the sixth most common cosmetic surgery performed by surgeons in 2016. It was also the most common body contouring technique after severe weight loss [13].

Although abdominoplasty is widely performed, it carries the highest risk of complications among all cosmetic procedures [14]. Complications observed in these patients include bleeding, skin or fat necrosis, wound destruction, surgical site infection, hematoma, pulmonary embolism, and seroma [14].

Despite the popularity of abdominoplasty surgery, patients are at a high risk of developing a complication of surgery that the most common one is seroma occurring in approximately 5 to 30% of patients [15–18]. The pathophysiology of seroma formation is thought to be due to extensive dissection in soft tissue, disruption of lymphatic and vascular ducts, and accumulation of fluids in the dead space between the flap of abdominal skin and the rectus muscle sheath [16, 19].

Seroma is the most common local complication associated with abdominoplasty, with an incidence rate of 1 to 57% and an average incidence of 10% [16, 20]. Although progress in abdominoplasty surgery has improved dramatically, the risk of complications remains high. Among these complications, seroma formation has the highest prevalence (5% − 43%) [15 and 23–21].

Seroma formation not only causes discomfort to the patient [24], but it also often requires multiple aspirations through the skin as well as additional surgical procedures [25]. This increases the care cost and reduces patient satisfaction [26, 27]. If left untreated, large seromas can cause other serious complications such as flap loss and necrosis, infection, and pseudo cist [28–30].

Body mass index (BMI), additional weakening, and a combination of other techniques such as liposuction are the most important predicting factors of seroma formation after abdominoplasty [31]. Several preventive measures have been proposed to reduce the rate of postoperative seroma, including drains, using compression garments, tissue adhesives, and progressive tension sutures (PTS) [32]. Seroma often develops between 10 and 20 days after abdominoplasty, so using a drain in the first 48 hours does not affect its formation. Drains immediately placed after surgery is only effective in preventing hematoma, not seroma [33].

Various studies have reported different prevalence of seroma after abdominoplasty. However, a comprehensive study was not found that generally shows the results of these studies worldwide. Therefore, due to the importance of this complication resulted from this common surgery and its negative effects on patients' quality of life, as well as the lack of general statistics about it worldwide, this

study aims to determine the global prevalence of seroma after abdominoplasty through a systematic review and meta-analysis study.

Methodology

In this systematic review and meta-analysis study, Scientific Information Database (SID), MagIran, ScienceDirect, Embase, Scopus, PubMed, Web of Science (WoS) databases and Google Scholar search engines were searched to find related studies. To access the target articles, the search strategy was determined for each database using the keywords "Prevalence, Epidemiology, Complications, Abdominoplasty, Seroma, Lipo abdominoplasty" and all their possible combinations. No time limitation was considered in the search process, and all related studies were identified, and the information of these studies was transferred to the information management software (EndNote X8). All possible related articles published by October 2020 were identified, and their information was transferred to EndNote. To maximize the comprehensiveness of the search, the list of sources used in all relevant articles found in the above search was manually reviewed.

Inclusion Criteria

Criteria for inclusion of studies include studies that examined the prevalence of seroma after abdominoplasty in the world, studies that were observational (non-interventional studies) and studies whose full texts were available.

Exclusion Criteria

Criteria for exclusion include unrelated studies, studies without sufficient data, repetitive studies, and unclear methodology.

Selection Process of Studies

Initially, the studies repeated in various searched databases were excluded from this study. The researchers compiled a list of the titles of all the remaining articles to obtain eligible articles by evaluating the articles in this list. In the first stage, i.e., screening, the title and abstract of the remaining articles were carefully studied, and irrelevant articles were removed according to the inclusion and exclusion criteria. In the second stage, i.e., evaluating the studies' competency, the full texts of the possible relevant articles remaining from the screening stage were examined according to the inclusion and exclusion criteria and irrelevant studies were also excluded in this stage. To avoid bias, all steps of reviewing sources and extracting data were independently performed by two researchers. If the articles were not included, the reason for their exclusion was mentioned. In cases where there was disagreement between two researchers, the article was reviewed by a third researcher.

Qualitative Evaluation of the Studies

In order to validate and evaluate the quality of articles (i.e., the validity of methodology and results), a checklist appropriate to the type of study was used. The STROBE checklist is commonly used to critically evaluate observational studies such as the present study. The STROBE checklist consists of six general scales/sections, including title, abstract, introduction, methods, results, and discussion. Some of these scales have subscales, and this statement consists of 32 items. In fact, these 32 items describe different methodological aspects of the study, including title, statement of the problem, the purpose of the study, type of study, statistical population of the study, sampling method, determination of appropriate sample size, definition of variables and procedures, data collection tools, statistical methods of analysis, and findings. Accordingly, the maximum score obtained from the qualitative evaluation in the STROBE checklist will be 32. Considering the score of 16 as the cut-off point, the articles with scores of 16 and above will be considered as articles with good and average methodological quality. In contrast, articles with scores under 16 are considered articles with poor methodological quality, and therefore they are excluded from the study [34].

Data Extraction

Information related to all final articles entered into the static review and meta-analysis process was extracted using a pre-prepared checklist. This checklist included the title of the article, name of the first author, year of publication, place of study, sample size, the prevalence of seroma after abdominoplasty in the world, type of operation, and age.

Statistical Analysis

To evaluate the heterogeneity of the selected studies, the I^2 index test was used (heterogeneities were divided into three categories: less than 25% (low heterogeneity), 25–75% (moderate heterogeneity) and more than 75% (high heterogeneity). In order to investigate the publication bias, the Egger test with a significance level of 0.05 and its corresponding Funnel plot was used. A sensitivity analysis

test was used to evaluate the effect of individual studies on the final result. In this study, meta-regression was used for additional analyses, which examines the relationship between the prevalence of seroma after abdominoplasty with the sample size and year of the study. Data analysis was performed using Comprehensive Meta-Analysis software (Version 2).

Results

In this study, systematic review and meta-analysis of data from studies on the global prevalence of seroma after abdominoplasty were systematically reviewed according to PRISMA guidelines. Based on the initial search in the target database, 814 possible related articles were identified and transferred to the information management software (EndNote). Twenty-six studies were also added through other resources. Out of a total of 840 studies identified, 95 were repetitive and were thus excluded. In the screening phase, out of 745 studies, the remaining 290 articles were excluded by studying their titles and abstracts based on inclusion and exclusion criteria. In the competency evaluation stage, out of 455 studies, the remaining 309 articles were excluded due to their irrelevance by studying the full texts of the articles based on inclusion and exclusion criteria. In the qualitative evaluation stage, by reading the full texts of the articles and based on the scores obtained from the STROBE checklist, out of the remaining 146 studies, three studies were excluded due to their low methodological quality, i.e., from a total of 32 scores that each article can get from the STROBE checklist. If the score is less than 16, the article is considered to have poor methodological quality. Therefore, 143 articles published between 1998 and October 2020 were entered in the final analysis (Fig. 1).

Based on the results obtained from the test (I^2 : 99.9) and considering the heterogeneity of selected studies, a random-effects model was used to combine the studies and estimate the prevalence. The heterogeneity between studies might be due to the differences in sample size, sampling error, year of study, and or place of the study. Out of 143 articles entered into the systematic review and meta-analysis with a sample size of 27,834, five studies were conducted in Asia, 55 studies in Europe, three studies in Africa and 80 studies in America. The smallest and highest sample sizes were related to the studies conducted by Hersant et al. (2016) (eight patients) [54] and Vieira-2 et al. (2018) (9638 patients), respectively [99]. The characteristics of the eligible studies included in the meta-analysis are given in Table 1.

The probability of publication bias in the spread of the outcomes of the global prevalence of seroma after abdominoplasty by funnel diagram and Egger test at a significant level of 0.05 indicated no bias of spread in the present study ($p = 0.298$) (Fig. 2).

Based on the results of this study, the global prevalence of seroma after abdominoplasty was obtained as 10.9% (95% CI: 9.3-3.6.6%) that the midpoint of each line segment shows the prevalence in each study, and the rhombic shape shows the prevalence in the population for the whole study (Fig. 3).

Meta-Regression Test

To investigate the effects of potential factors in the heterogeneity of seroma prevalence after abdominoplasty in the world, meta-regression was used for three factors: sample size, age of study participants and year of study (Figs. 4, 5, 6). According to Fig. 4, the global prevalence of seroma after abdominoplasty decreases with an increase in the sample size, which is statistically significant ($p < 0.05$). Moreover, in Fig. 5, it was reported that the global prevalence of seroma after abdominoplasty decreases with an increase in the year of the study. This difference was also statistically significant ($p < 0.05$). In Fig. 6, it was also reported that with the increase in the age of study participants, the global prevalence of seroma after abdominoplasty decreases, which was also statistically significant ($p < 0.05$).

Analysis of Subgroups

Table 2, which presents the prevalence of seroma after abdominoplasty by continents, reports these changes in Asia, Europe, Africa, America, and Australia, with the highest prevalence of seroma (12.8%) in the European continent (95% CI:10.9-3.9% (Table 2).

Discussion

Abdominoplasty is a popular surgical procedure in which extra skin and abdominal fat are removed to improve the contouring of the abdomen [88–95]. Extensive weight loss (MWL) causes the excess soft tissue in several places in the body, especially in the abdominal wall. Extra skin can lead to various complaints such as integrated skin infections, unpleasant odors, problems in the back, neck, and pain during work and exercise. Abdominoplasty usually helps to improve the quality of life and performance of patients with the transformation of body contour through reducing excess fat and skin tissue [96–111]. This surgery can be beneficial for anyone who has a lot of skin and fat tissue in the lower abdomen, a condition that is commonly seen in female patients after pregnancy, obesity or ageing

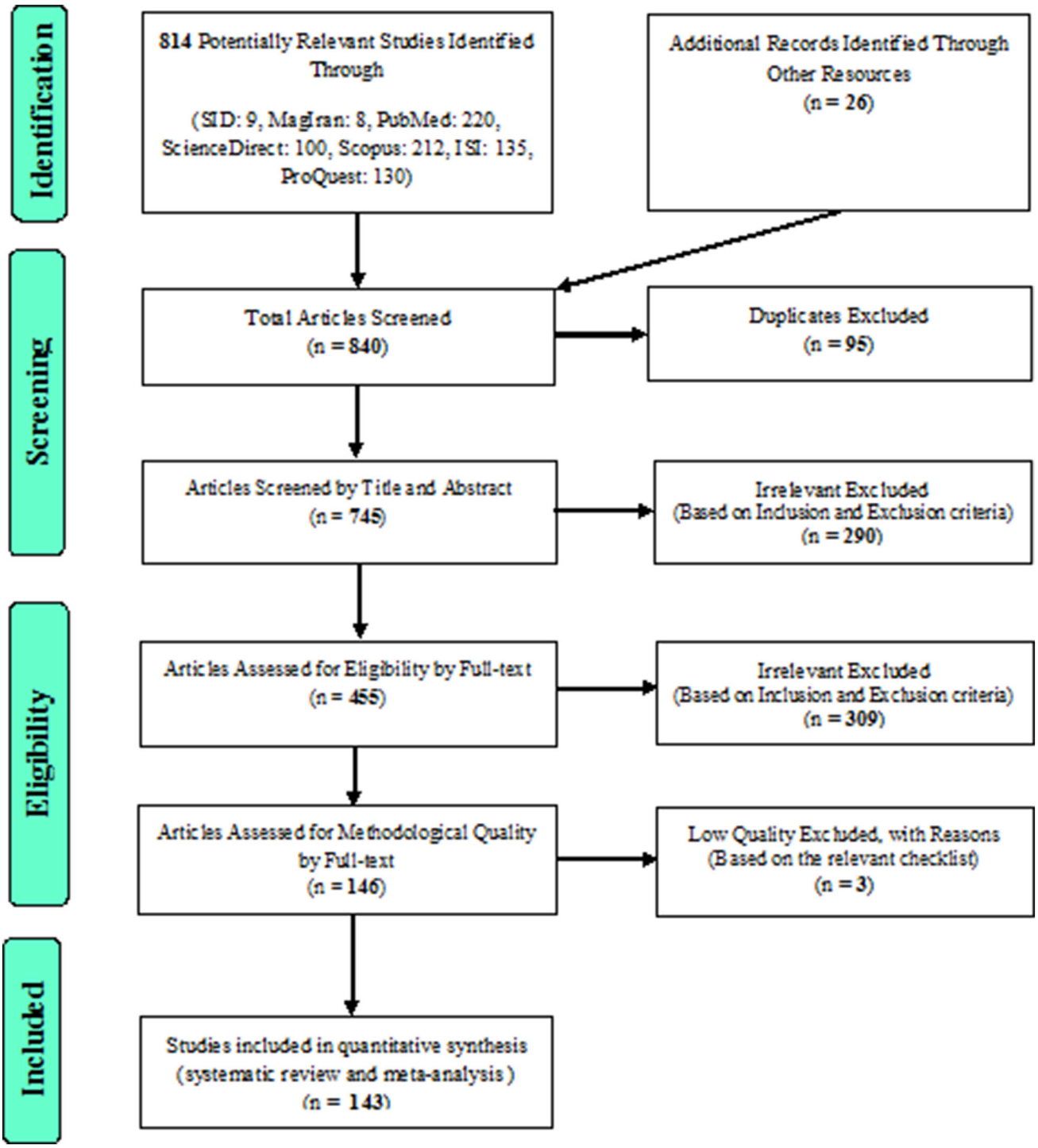

Fig. 1 Flowchart on the stages of including the studies in the systematic review and meta-analysis (PRISMA 2009).

[112–128]. Despite updated evidence, new clinical trials and technical advances, there are still high complications associated with abdominoplasty surgery [129–135]. These complications include seroma, hematoma, flap necrosis, infection, fat necrosis, and wound destruction [136–143]. These complications lead to dissatisfaction, long-term recovery, unexpected costs, physical and mental suffering, and it might be dangerous or fatal [137, 144, 145].

Irrespective of outpatient or inpatient care, abdominoplasty procedures typically last longer than one hour and therefore have at least a "moderate" risk for developing thromboembolic complications. When patients undergoing

Table 1 Characteristics of included studies prevalence of seroma after abdominoplasty

Author [references]	Publication date	Country	Age (year)	Sample size	Prevalence (%)	Type of abdominoplasty
Omranifard [35]	2011	Iran	34.3±8.5	100	3.5	–
Chang [36]	2013	Taiwan	32	88	3.4	Videoendoscopy
Bhave [37]	2018	India	–	204	1	–
Cohen [38]	2018	Israel	41	218	9.6	–
Jabaiti [39]	2009	Jordan	40.8	116	12.9	–
Batac [40]	2019	Island	43.7	83	20.5	–
Brito [41]	2020	Portugal	43.1±10.4	191	20.9	–
Marsh-1[42]	2015	UK	–	44	20.5	sharp dissection
Marsh-2 [42]	2015	UK	–	58	17.2	electrocautery dissection
Dillerud [43]	1990	Norway	49	487	1	Lipo/Abdominoplasty
Gonçalves-1 [44]	2017	Portugal	39.1±8.9	21	19	classic
Gonçalves-2 [44]	2007	Portugal	38.3±7.8	30	6.7	Scarpa fascia preservation
Sozer [45]	2018	Turkey	–	1000	19	circumferential lipoAbdominoplasty
Grieco[46]	2015	Italy	51	25	36	–
Persichetti[47]	2005	Italy	52.5	42	7.1	–
Jones[48]	2008	UK	46.2	16	25	–
Dini[49]	2008	Italy	43.6	41	26.5	–
Koller[50]	2012	UK	40	50	8	–
Schlosshauer[51]	2019	Germany	45.3±11.6	26	15.4	Conventional electrosurgery
Garcia [52]	2014	Spain	43.5±10.7	72	23.6	–
Momeni[53]	2009	Germany	42.8	139	20.9	–
Stewart[15]	2006	UK	46	278	5	–
Hersant[54]	2016	France	47.5±10.9	8	12.5	–
Dutot[55]	2018	France	41	1128	2.7	–
Bracaglia[56]	2012	Italy	42.15±8.1	16	6.3	–
Giordano[57]	2020	UK	40.5± 9.9	37	13.5	–
Hauck[58]	2019	Germany	46.3	12	16.7	–
Khan-1[59]	2008	UK	39.5 ± 9.5	96	27.1	without progressive tension suture
Khan-2[59]	2008	UK	37±6.7	50	1	with PTS
Khan-3[59]	2008	UK	39.5±9.5	96	22.9	lipoabdominoplasty without PTS
Khan-4[59]	2008	UK	37±6.7	50	8	lipoabdominoplasty with PTS
Ferreira-1[60]	2013	Portugal	38.50±9.27	80	18.8	without preservation of the Scarpa fascia
Ferreira-2[60]	2013	Portugal	40.64±8.31	80	2.5	with preservation of the Scarpa fascia
Swedenhammar-1 [61]	2018	Sweden	41.4	69	11.6	operated in 2011
Swedenhammar-2 [61]	2018	Sweden	38.6	70	7.1	operated in 2010-2012
Swedenhammar-3 [61]	2018	Sweden	46.8	70	8.6	operated in 2013–2014
Quaba[62]	2015	UK	45	271	7.7	-
Mayer[63]	2018	Argentina	27	22	4.5	–
Sforza-1[64]	2015	UK	41.2±7.98	100	12	no quilting sutures+ two drains
Sforza-2[64]	2015	UK	40.2±8.28	226	0.2	with quilting sutures + two drains
Sforza-3[64]	2015	UK	41.5±8.13	88	0.6	with quilting sutures+one drain
Breiting[65]	2011	Denmark	42	21	4.8	
Khan-5[66]	2012	UK	39.5±9.5	53	26.4	With Liposuction without PTS
Khan-6[66]	2012	UK	37±6.7	24	8.3	With liposuction and PTS
Khan-7[66]	2012	UK	40.6±10.9	44	1.1	With liposuction+PTS entire wall abdomen

Table 1 continued

Author [references]	Publication date	Country	Age (year)	Sample size	Prevalence (%)	Type of abdominoplasty
Mohammad[21]	1998	Germany	55	80	30	–
Pilone[67]	2020	Italy	–	71	31	–
Larsen[68]	2007	Netherland	–	25	24	–
Iglesias[69]	2015	Mexico	–	25	8	–
Skillman-1[24]	2014	UK	–	60	6.7	ligation by clip or suture
Skillman-2[24]	2014	UK	–	30	33.3	Use of diathermy
Ovens[70]	2009	UK	–	40	25	with quilting sutures
Korchin-1[71]	2005	Puerto Rico	–	43	18.6	without Fibrin Sealant
Korchin-2[71]	2005	Puerto Rico	–	48	4.2	with Fibrin Sealant
Hunecke[72]	2019	Germany	43.7	121	7.4	–
Valença-1[73]	2015	Portugal	41.03±8.07	39	1.3	With scalpel
Valença-2[73]	2015	Portugal	38.50± 9.2	80	18.8	With Diathermocoagulation
Beer-1[74]	2010	Switzerland	45±10	30	13.3	in a private clinic
Beer-2[74]	2010	Switzerland	43 ± 16	30	1.6	in a public hospital
Pilone-1[75]	2015	Italy	35 ± 9.5	15	53.3	traditional circular lipo/abdominoplasty
Pilone-2[75]	2015	Italy	38 ± 11.6	15	6.7	slow-clotting version of fibrin sealant
Weiler[76]	2010	USA	41.53	173	3.5	Lipoabdominoplasty
Villegas[77]	2014	Canada	47 ± 12	42	9.5	TULUA Modifications
Hoyos[78]	2018	Colombia	–	736	7.3	circumferential lipoabdominoplasty
Spiegelman-1[79]	2006	Canada	41.2± 7.7	37	18.9	Inpatient Population
Spiegelman-2[79]	2006	Canada	37.5±10.4	32	25	Outpatient Population
Perez[80]	2012	USA	46.4	55	1.8	With Fibrin Sealant
Restrepo[81]	2004	Colombia	51	76	10.5	lipoAbdominoplasty With Anchor Plication
Brink-1[82]	2009	USA	–	151	13.9	Abdominoplasty
Brink-2[82]	2009	USA		30	16.7	with flank liposuction
Warner[83]	2009	USA	42	58	1.7	+ProgressiveTension +Barbed Suture
Rodby[27]	2011	USA	50	113	8.8	lipoAbdominoplasty+Plication Superficial Fascia - Drains
Avelar[84]	2002	Brazil	–	97	2.1	–
Kim-1[22]	2006	USA	42.7	39	35.5	abdominoplasty
Kim-2[22]	2006	USA	42.6	79	29.1	with flankliposuction
Kim-3[22]	2006	USA	–	19	42.1	with Ultrasound Liposuction
Kim-4[22]	2006	USA	–	60	25	lipoAbdominoplasty
Nemerofsky[85]	2006	USA	–	200	16.5	–
Lee-1[86]	2012	USA	47.6	33	3	with fibrin sealant
Lee-2[86]	2012	USA	51.4	32	6.3	without fibrin sealant
Dabb[87]	2004	USA	–	32	15.6	–
Matos[88]	2006	Brazil	–	211	0.9	Lipoabdominoplasty
Najera-1[89]	2011	USA	41.6	75	16	Abdominoplasty-Only
Najera-2[89]	2011	USA	44	125	31.2	Abdominoplasty +Flank Liposuction
Smith[90]	2008	USA	43 ± 8.3	159	11.3	–
Hamra[91]	2016	USA	53	72	2.8	–
Sozer[92]	2007	Brazil	42 ± 9	151	4	–
Macias-1[93]	2016	USA	44.3	324	8.6	with PTS
Macias-2[93]	2016	USA	44.1	127	2.4	with drains
Khan-1[94]	2006	USA	42.4 ±11.6	54	18.5	Abdominoplasty

Table 1 continued

Author [references]	Publication date	Country	Age (year)	Sample size	Prevalence (%)	Type of abdominoplasty
Khan-2[94]	2006	USA	37.7 ± 7.7	49	6.1	PTS Abdominoplasty
Stokes[95]	2007	USA	45.2	48	20.8	–
Nahas[16]	2007	Brazil	43.7	21	9.5	–
Bromley-1[96]	2018	Brazil	46.7	21	76.2	abdominoplasty
Bromley-2[96]	2018	Brazil	45.6	25	12	with the use of 11 PTS and drains
Bromley-3[96]	2018	Brazil	48.3	22	9.1	with theuse of 22 PTS and drains
Friedman-1[97]	2010	USA	45.13	345	2.3	Abdominoplasty
Friedman-2[97]	2010	USA	47.84	154	3.2	Fleur-de-Lis Abdominoplasty
Laverson[98]	2006	USA	–	25	4	–
Vieira-1[99]	2018	USA	–	1553	5.5	–
Vieira-2[99]	2018	USA	43.58±12.23	9638	3.6	Lipo/Abdominoplasty
Martino[100]	2015	Brazil	34.8	21	35.1	–
Neaman[23]	2013	USA	44	1008	15.4	–
Barone[101]	2007	USA	43	19	5.3	–
Pollock-1[102]	2012	USA	46.5	142	0.7	Lipo/Abdominoplasty
Pollock-2[103]	2004	USA	42	65	0.8	abdominoplasty with PTS
Andrades-1[104]	2007	Chile	40.7± 5.8	10	50	no drains no PTS
Andrades- 2[104]	2007	Chile	38.5± 4.6	15	33.3	with PTS alone
Andrades-3[104]	2007	Chile	40.1 ± 9.5	15	33.3	with drains alone
Andrades- 4[104]	2007	Chile	39.7 ± 6.1	15	26.7	with PTS and drains
Swanson-1[105]	2013	USA	43.38	150	5.3	Lipo/Abdominoplasty
Swanson-2[105]	2013	USA	40.57	17	5.9	Abdominoplasty only
Rosen[106]	2020	USA	45	445	4.7	–
Antonetti[107]	2010	USA	–	124	9.7	–
Rosen[108]	2011	USA	43.6	34	8.8	–
Gallagher-1[109]	2018	USA	43.4	35	11.4	thepost–bariatric surgery MWL
Gallagher-2[109]	2018	USA	46.4	137	2.2	normal-weight without MWL or bariatric surgery
Gray[110]	2012	USA	40	206	19.4	–
Shermak[111]	2008	USA	42	150	12	–
Martino-1[112]	2010	Brazil	34.8	21	35.1	without quilting sutures
Martino-2[112]	2010	Brazil	34.7	17	2.8	with quilting sutures
Martino-3[112]	2010	Brazil	34.9	20	10	lipoabdominoplasty
Gould-1[113]	2018	USA	44.8 ± 11.2	270	2.2	lipo-abdominoplasty with PTS
Gould-2[113]	2018	USA	48.3± 9.8	29	6.9	with PTS without liposuction
Gould-3[113]	2018	USA	43.8±10.1	207	9.2	with drain and liposuction
Gould-4[113]	2018	USA	44.4±10.2	113	6.2	with drain without liposuction
Restifo[114]	2019	USA	42.48	723	14.4	-
Stevens[115]	2007	USA	43	519	10.6	-
Arantes-1[116]	2010	Brazil	–	28	3.6	with adhesion sutures
Arantes-2[116]	2010	Brazil	–	32	3.1	with adhesion sutures+ drains
Villegas[117]	2020	Colombia	40.6	164	4.9	TULUA Lipoabdominoplasty
Fernandes[118]	2018	Brazil	43	245	10.2	–
Holzman[119]	2015	USA	45.2	65	18.5	–
Nurkim-1[120]	2001	Brazil	35.6	24	25	used a latex drain
Nurkim-2[120]	2001	Brazil	35.6	24	4.2	used a rigid suction drain tube
Nurkim-3[120]	2001	Brazil	35.6	21	42.9	did not use any drains

Table 1 continued

Author [references]	Publication date	Country	Age (year)	Sample size	Prevalence (%)	Type of abdominoplasty
Ramirez[121]	1999	USA	–	132	3	-
Duncan[122]	2007	USA	–	75	0.7	lipoabdominoplasty without panniculus undermining
Rodriguez[123]	2011	USA	–	100	0.5	Lipoabdominoplasty
Neaman[17]	2007	USA	43	207	17.4	–
Ghnnam[124]	2016	Egypt	36± 4.9	67	7.5	–
El-Meligy-1[125]	2018	Egypt	35.20±9.07	18	2.6	Scarpa's fasciapreservation
El-Meligy-2[125]	2018	Egypt	35.50 ±9.57	20	15	classic abdominoplasty

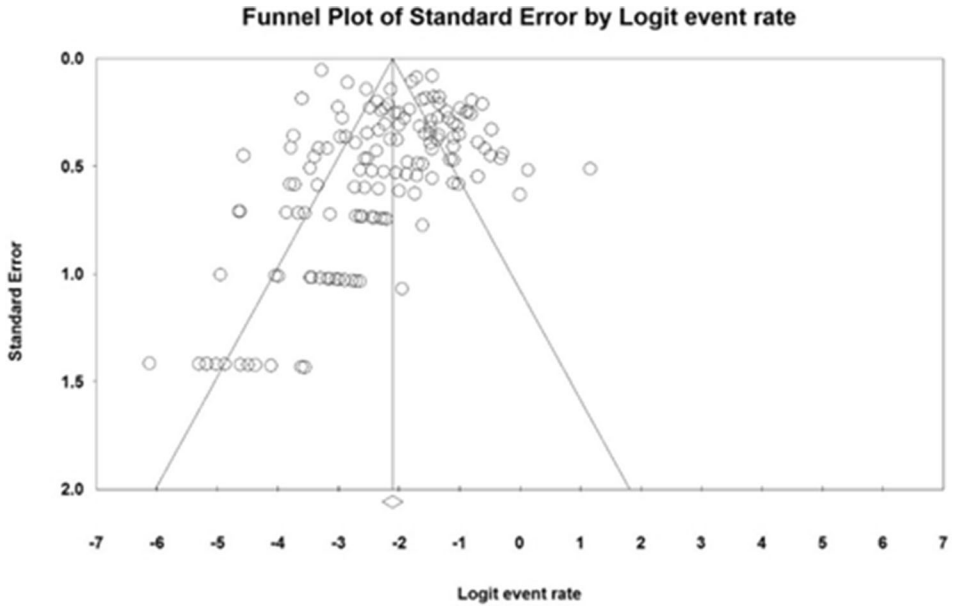

Fig. 2 Funnel plot of results for the global prevalence of seroma after abdominoplasty

an abdominoplasty are older than 40 years of age and have additional predisposing risk factors, the risk of thromboembolic complications increases to "high" or "highest" [74, 136–145]. One of the exposing risk factors is the length of immobilization [146].

Beer and et al. reported a significant difference in the rate of seroma across the two groups. It seems plausible that reducing the rate of seroma after abdominoplasties may be achieved by increasing the duration of postoperative immobilization by up to 48 h. After being appropriately informed about the advantages and drawbacks of this regime, the patient should perhaps be invited to decide between a justifiable longer stay in bed under mechanical and chemical thromboembolism prophylaxis or a shorter stay in bed that is accompanied by a significantly higher risk of developing a seroma [74].

The most common types of surgery that result in seromas include body contouring, such as liposuction or arm, breast, thigh, or buttocks lifts, breast augmentation or mastectomy hernia repair, abdominoplasty, or a tummy tuck [74, 136–145], the surgical team will place drainage tubes in and around the incision to try to prevent a seroma. The drainage tubes may remain in the body for a few hours or a few days after the surgery to prevent fluid buildup. In many cases, the use of drainage tubes will be sufficient for preventing a seroma. However, that is not always the case, and a week or two after the procedure, there may be signs of fluid buildup near the incision [140–145].

Several factors increase the risk of developing a seroma after a surgical procedure. These risk factors include extensive surgery, a procedure that disrupts large amounts of tissue, a history of seromas following surgical procedures [74].

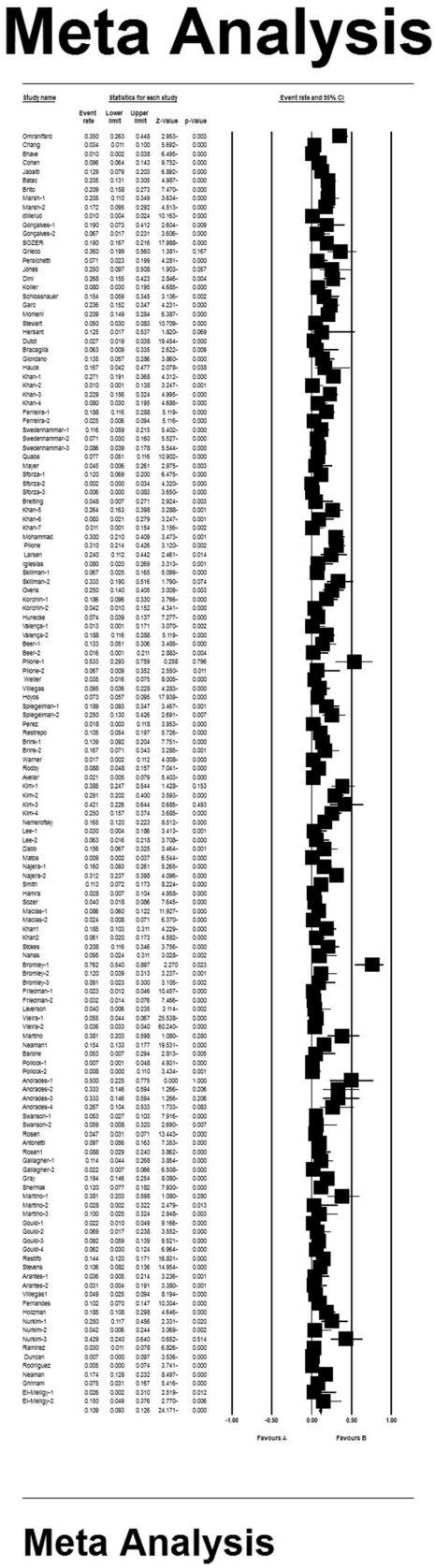

Fig. 3 Seroma prevalence after abdominoplasty in the world and 95% confidence interval.

Seroma is the most common early complication after abdominoplasty [16, 28, 146], which forms the abdominal rectus muscle in the dead space between the flap and fascia and often requires frequent outpatient visits for aspiration, that in turn increases the risk of infection, long-term recovery, and additional surgical treatment [134, 146]. Due to the importance of this disease and the lack of a worldwide meta-analysis study that shows general statistics in this regard, the present study was aimed to determine the prevalence of seroma after abdominoplasty in a systematic review and meta-analysis study using studies conducted worldwide.

According to this systematic review study and meta-analysis, the global prevalence of seroma after abdominoplasty was 10.9% (95% confidence interval: 9.6-3.6-3.6%). The highest prevalence of seroma after abdominoplasty was related to the study by Bromley et al. [96] with 76.2%. The lowest prevalence was reported in the study by Sforza et al. [64] with 0.2%. According to the meta-analysis and systematic review conducted by Seretis et al. (2017), the prevalence of seroma after abdominoplasty in nine studies was reported to be 0.26% [145]. The reason for the differences between our study and this study is that the number of articles studied in the present study is higher (143 articles in the present study versus nine articles in the study by Seretis et al.). Also, the present study examined patients of different races and geographical areas worldwide.

Regarding the change in population structure in different countries of the world, it seemed necessary to carefully study the prevalence of seroma after abdominoplasty in different continents to attract the attention of planners to this process and its consequences. Therefore, considering the analysis of subgroups in different continents, the highest prevalence of seroma is related to the European continent with 12.8% (95% confidence interval: 10.3–3.9%). The lowest is related to the Asian continent with 8.3%. (95% confidence interval: 3.8–1.8%).

The most comprehensive study in terms of sample size was a study conducted by Vieira-2 et al. (2018) in the USA [99], which reported a 3.6% prevalence of seroma after abdominoplasty, which differs from the overall results of the present study. However, it is consistent with the results of meta-regression, which decreases with an increase in sample size and year of the prevalence of seroma after abdominoplasty in the world.

Considering the results obtained from meta-regression, the global prevalence of seroma after abdominoplasty decreases with an increase in the year of the study. This declining trend might be related to appropriate preventive measures and basic surgical techniques in different parts of the world. However, care measures are necessary to be taken in this regard. Several surgical strategies have been

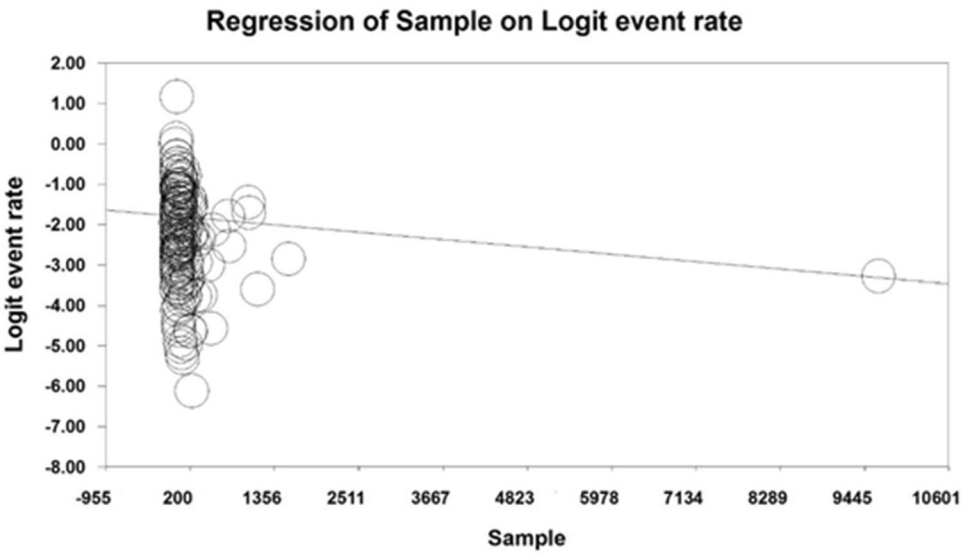

Fig. 4 Meta-regression diagram of seroma prevalence after abdominoplasty in the world by sample size

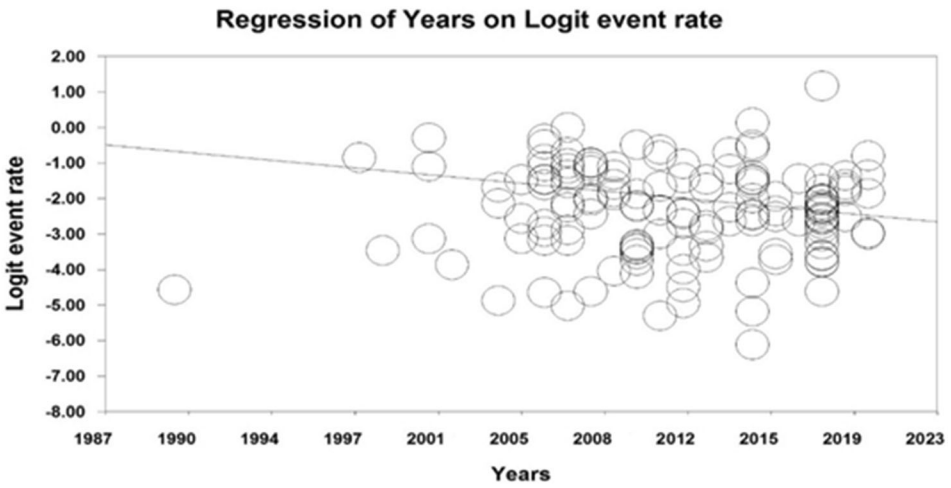

Fig. 5 Meta-regression diagram of seroma prevalence after abdominoplasty in the world by year of the study

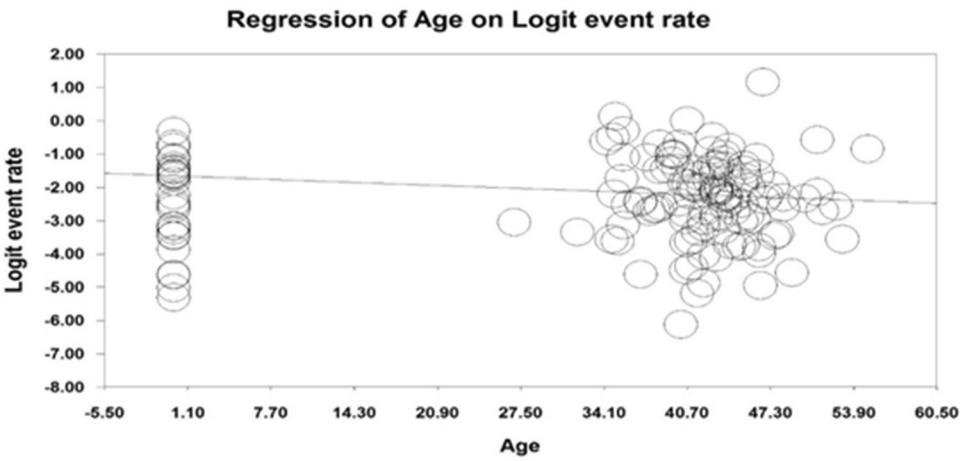

Fig. 6 Meta-regression chart of seroma prevalence after abdominoplasty in the world in by the age of study participants

proposed to reduce the rate of seroma, such as progressive tension sutures (PTS), preservation of scarp fascia, lipo abdominoplasty, various dissection methods, and using adhesives and fibrin seals [135–140]. Although using drain is associated with a significant increase in postoperative pain and complications such as reverse migration and

Table 2 Prevalence of seroma after abdominoplasty in population by different continents

Continents	Number of articles	Sample size	I^2	Egger Test	Prevalence % (95 % CI)
Asia	5	726	93.1	0.132	8.3 (95 % CI: 3.1-20.8)
Europe	55	5945	84.5	0.052	12.8 (95 % CI: 10.3-15.9)
America	80	21058	91.6	0.071	10.1 (95 % CI: 8.3-12.4)
Africa	3	105	0	0.723	8.9 (95 % CI: 4.6-16.5)

bacterial infection, the closed suction drain has been considered a standard of care for preventing seroma for decades [141, 142].

Abdominoplasty surgery is one of the most common methods, after which between 5 and 50% of seroma may occur for more than five years. While Baroudi and et al. reported in their study report that using the quilting suture technique in 130 patients, serum complications did not occur after abdominoplasty [137].

This study also reports that for the prevention and treatment of seroma after abdominoplasty. Patients are instructed to rest at home during the first week of the postoperative period in a supine position with the trunk slightly elevated, alternating with a standing position or semi-upright on a sofa. They should avoid long hours of sitting straight because this position folds the flap, thereby compromising the adhesion between the two surfaces [137].

Baroudi et al. reported that in patients treated with topical stimulants or revision surgery with removal of the pseudobursa or local suction, the bursa was opened, and the solder was sutured without cutting the pseudomembrane, as well as using a bandage and pressure for ten days there was no recurrence of serum [137].

The funnel plot was used to show publication bias in studies included in the meta-analysis process and showed that the possibility of bias is rejected.

The increasing number of body contouring procedures such as abdominoplasty surgery has probably been related to more obesity surgeries and extra weight loss. It increases the relationship between self-esteem and body image by patients and social media [17, 143]. Patient satisfaction is the primary goal of elective cosmetic surgery, and postoperative seroma dissatisfaction bothers plastic surgeons and patients because, in addition to the increased risk of infection and impaired wound healing in patients with seroma, the need for additional visits to the clinic and the possibility of reoperation carry a heavy burden for patients [144]. Although seroma can generally be aspirated after diagnosis in the office, it can lead to subsequent anxiety for both the patient and the surgeon [138].

Since seroma formation following abdominoplasty has many negative consequences for the patient, supportive actions and treatments are considered useful to achieve better treatment techniques and reduce the symptoms of the disease. Also, in recent years, the evaluation of the patient's postoperative condition has been considered an important issue in health care because these studies can provide useful information to health-care providers, enrich health care interventions, improve the quality of services, and ultimately improve the quality of life of these people.

Limitations

One of the limitations of this study is that some samples were not based on random selection. Also, non-uniform reporting of articles, non-uniform implementation method, and the lack of matching and unavailability of the full texts of the articles presented at the conference can be mentioned as another limitation. Additionally, due to the limited number of articles in some continents and the lack of uniform distribution of articles in different parts of the world, subgroup analysis was performed in different continents or racial groups with a limited number of articles. Therefore, more studies are suggested to be conducted on different racial groups in different parts of the world in order to better show the prevalence of seroma after abdominoplasty in different populations.

Conclusions

This study shows that the prevalence of seroma after abdominoplasty is high globally, so physicians and specialists must consider its importance and take controlling and treatment measures seriously.

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Availability of Data and Materials Datasets are available through the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval Ethics approval was received from the ethics committee of deputy of research and technology, Kermanshah University of Medical Sciences (IR.KUMS.REC.1399.804).

Informed Consent Informed consent is not applicable to this type of study.

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