Circumferential Contouring of the Lower Trunk: Indications, Operative Techniques, and Outcomes-A Systematic Review

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INTRODUCTION

The increasing prevalence of obesity[1] and the development of bariatric surgery[2] have led to the gradual development of skin redraping techniques. Among them, circumferential body contouring allows the correction of redundant skin on the lower trunk after massive weight loss.

Several techniques have emerged since "circumferential dermolipectomy" was first described in 1940[3]. In the 1960s, Gonzalez-Ulloa[4] and Villain[5] described "belt lipectomy" and "circular lipectomy," implying circular resection performed up to the muscular aponeurosis at depth, with a posterior scar located at the belt line. In 1993, Lockwood[6] described the "lower body lift," which merged the medial thigh lift[7] with the transverse thigh-buttock lift[8] and incorporated two major innovations: a resection that preserved the superficial fascia and a lower-sited scar to help lift the lateral thigh and buttocks.

Carwell[9] and Van Geertruyden[10] described "circumferential torsoplasty," derived from belt lipectomy[4], and Lockwood improved his original technique[11].

The main innovations were high superior[12] and high lateral tension[13] abdominoplasty, buttock-autologous augmentation with[14] or without[15–17] a flap, and lipogluteoplasty[17, 18].

Different techniques have been described under different names ("mid-body lift"[19], "circumferential body lift"[20], "central body lift"[21], "circumferential abdominoplasty"[22], "circular lipectomy"[23]); all derive from belt lipectomy or the lower body lift, depending on the level of posterior resection.

No systematic review of the literature on circumferential contouring of the lower trunk has been conducted to date. The aim of this review was to summarize the indications for, procedures and outcomes of, and patient satisfaction with these techniques.

MATERIALS AND METHODS

We undertook this review in June 2015 in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement[24, 25].

Our protocol was AMSTAR (Assessing the Methodological Quality of Systematic Reviews)–compliant and is available online at: www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015020680.

Eligibility criteria

The inclusion criteria were: published reports (original articles, randomized controlled trials, controlled clinical trials, retrospective or prospective observational studies, case reports, letters to the editor, and technical

descriptions) that included patients undergoing circumferential contouring of the lower trunk, performed as single-step surgery.

The exclusion criteria were: two-step surgery, circumferential contouring of the upper trunk, isolated abdominoplasty or buttock lift, and circumferential liposuction without skin resection. We excluded all studies lacking original data and studies in any language other than English or French.

Search strategy

Eligible studies were identified from the PubMed and Cochrane Library databases using the following keywords combined with Boolean operators: «bodylift» OR «body lift» OR «circumferential body contouring» OR «circumferential abdominoplasty» OR «lower body lift» OR «bodylifting» OR «circumferential contouring» OR «belt lipectomy» OR «circumferential dermolipectomy» OR «truncal bodycontouring» OR «circumferential belt lipectomy» OR «circular lipectomy». Reference lists of selected articles were also examined to identify additional potentially eligible articles.

Data collection

Data were extracted independently by two researchers (RC, ADR), and disagreements were resolved by a third senior author (NB).

Data were collected on: authors, publication date, country, type of study and level of evidence, number of patients, indications, demographic data (body

mass index [BMI], weight loss before surgery, medical history), perioperative care, operative technique, outcomes and complications.

Statistical analysis

Statistical analysis was performed using Prism 5 (GraphPad Software, La Jolla, CA, USA). A descriptive analysis of all data was carried out and results were expressed either in medians with inter-quartile-range (IQR) or in means with 95% confidence intervals.

RESULTS

Among the 3,424 articles initially identified by the search, 42 were finally selected (Fig. 1). Published between July 1960 and March 2015, they included 1,748 patients. Most had a low level of evidence (Table 1). The publications originated mainly from Western countries (Table 2, Fig. 2). Patients' characteristics, indications, and operative techniques are summarized in Tables 3 and 4.

Indications

The first described techniques[4, 5, 26–28] were indicated for obese women with redundant panniculus at the waistline following pregnancy or dieting. Lockwood's[6, 29] lower body lift no. 1 was indicated for normal-weight

patients with soft-tissue laxity of the lower trunk and thighs. Carwell[9] was the first to include post-bariatric patients (n = 6).

The most frequently reported indication was massive weight loss[10, 15, 19, 20, 22, 27, 30–45] secondary to bariatric surgery or dieting, which created excess circumferential skin of the lower trunk. Posteriorly, belt lipectomy and derived techniques better treated hips and back rolls, whereas lower body lifts better treated buttocks and lateral thigh ptosis[33]. Belt lipectomy could also treat excess fat localized in the flanks in overweight or obese patients[4, 23, 31, 46].

Tobacco use was contraindicated in four studies[6, 15, 30, 37]. Contrarily, surgery on smokers was reported in 10 studies[10, 27, 31, 35, 39, 41–43, 47, 48]. Four studies each included surgery on patients with high blood pressure[21, 35, 39, 43] and diabetic patients[21, 35, 43, 47].

Preoperative assessment

Preoperative assessments were reported on in eight publications[19, 20, 32, 39, 40, 42, 44, 48]. Assessments included preoperative correction of anemia[14, 39, 40, 42, 44]; measurement of total protein[40, 44], prealbumin and albumin[44], glucose[44], iron[44], calcium[44], magnesium[44], thiamine[44], complete cell count[44], blood urea nitrogen[44], creatinine[44], electrolytes[19, 44, 48], and liver function[44]; and urinalysis[44]. Only two authors recommended follow up by a dietician[20] or nutritionist[42].

Operative technique

Operative markings

No difference in marking between men and women was reported. Markings were usually made while patients were standing[4, 33, 36–38, 43] and completed in the supine position[34, 35, 47]. “Pinch tests”[4, 21, 27, 42, 43, 46, 47] were used to estimate the amount of tissue to be resected. Anteriorly, stretching forces proceeded from top to bottom, and posteriorly they were inverse[48]. Techniques derived from belt lipectomy resulted in scars situated at the waistline, whereas lower body lifts left scars situated at the bikini line (Fig. 3).

For belt lipectomy, the upper resection line was drawn first posteriorly, and ideally was placed at the superior margin of the flank rolls[19]. Then, a horizontal inferior line was drawn that crossed the interspinal line approximately 5 cm above the intergluteal groove[23].

For lower body lift, the lower resection line crossing the interspinal line inside or at the top of the gluteal cleft[48] was marked first. The upper resection line was usually 5 cm inferior to L5[36].

For both techniques, the upper resection line was usually V-shaped[20, 26, 27, 36] to preserve the gluteal aesthetic unit and decrease tension in the middle line. The upper line joined the central point to the posterior superior iliac spine[36, 43]. The height of tissue resected posteriorly ranged from 5 to 7 cm in the middle[23] and 10 to 15 cm laterally[21]. A grid pattern could be

marked to facilitate closure[37]. The buttock flap was marked, if operated on, and ended laterally at the lateral limit of the inferior gluteal fold[14].

Laterally, the scar had to be located at the level of the anterior superior iliac spine[37]. On the mid-axillary line, the height of resection ranged from 10 to 25 cm[11],[23],[48]. A triangular lateral excision to correct transversal lateral thigh excess was performed in some cases[49].

Anteriorly, the pattern joined the abdominoplasty scar, with a lower point of resection placed in the abdominal fold or 7 cm from the vulvar commissure or the base of the penis[48]. Associated medial thigh lift with a horizontal scar was reported by two authors[6, 39]. Gonzalez-Ulloa[4] associated “triangles of compensation” anteriorly and posteriorly to correct the transversal excess and to diminish the prominence of the mons Venus, when necessary. Liposuction areas were marked preoperatively.

Patient positioning

Three possibilities for positioning were reported:

- two-step positioning in the supine position first, then prone[4, 5, 19, 27, 33, 40, 46];
- two-step positioning in the prone position first, then supine (the most commonly reported technique)[9, 10, 14, 15, 20–22, 36–39, 42, 43, 48]; and
- three-step positioning, with the patient supine and in two lateral decubitus positions[6, 23, 26, 34, 35, 47, 49, 50]. This installation was chosen for better control of the lateral thigh lift and when lateral thigh resection was required[49], and was used in the USA[6, 23, 26, 34, 35, 49, 50] and UK[47].

We describe the different surgical techniques using the most common positioning sequence.

Posterior Resection

The depth of resection varied among studies (Fig. 4). Belt lipectomy–derived techniques used resection deep to the muscular fascia[4, 5] or to the superficial fascia[19, 21]. The resection depth for the lower body lift was also to the muscular fascia[26, 35, 37, 38, 40, 43] or the superficial fascia[6, 11, 15, 39, 47]. Lockwood[6] was the first to report the associated use of liposuction.

In 2002, the first buttock auto-augmentation with a flap[14] was reported (Fig. 5). The flap measured approximately 10 × 25 cm and extended laterally to the end of the buttock fold. Other derived flaps were described: a lateral perforator-based deepithelized dermal fat flap[34], a random medially based flap[33], the "moustache flap"[20], and a superior gluteal artery perforator flap[36]. Augmentation flaps were reported in 9 of 42 publications.

The technique of buttock augmentation without flap included sutures in an outer–inner direction[15, 17, 33] (Fig. 6) or a “purse string” suture[16].

Finally, the most conservative technique for posterior resection was lipogluteoplasty, which involved skin-only resection after liposuction under the zone to be resected[18].

Anterior resection

This approach consisted of abdominoplasty associated with rectus fascia plicature, where a diastasis existed, and transposition of the umbilicus. It was combined in some cases with liposuction[21, 37, 38, 48] and a high superior tension[42] or high lateral tension technique[14, 40]. Associated performance of monsplasty to treat mons Venus ptosis was also reported[40].

Thigh lift

Lockwood's[6] lower body lift no. 1 provided a medial thigh lift with a horizontal scar in the inguinal fold and an anchor to the Colles fascia. Kitzinger[39] also reported the associated performance of a medial thigh lift.

The lateral thigh lift, as described in Lockwood's[11] lower body lift no. 2, was used much more frequently[10, 23, 26, 31, 34, 35]. It consisted of liposuction and minimal undermining of the trochanteric region to lift the lateral thigh. Suspension points were eventually added[14, 48]. Davison[49] performed triangular resection of the lateral thigh to correct excess skin in this area.

Outcomes and complications

All main data were summarized in Table 5. The median percentage of patients who had a complication was 36,55[26,63-45,65]%. The median revision rate for a non-aesthetic purpose (wound dehiscence, abscess, skin necrosis, fat necrosis, seroma evacuation, hematoma) was 3,5 [0,25-6]%. The median revision rate for aesthetic purpose (scar revision, secondary

liposuction or fat injection and correction of omblic) was 0[0-5,75]%. In the posterior step, 6 cases of gluteal fat necrosis were reported in 4 series[20, 33, 34, 36] and 48 cases of gluteal hypoesthesia were reported in two studies[32, 48].

Antibiotic prophylaxis

Antibiotic prophylaxis was not well codified (Table 6). Some authors recommended intraoperative prophylaxis[10, 22, 23, 42]; others recommended antibiotherapy for 24 hours[38], 48 hours[14, 32], 3 days[39], or 5 days[47] postoperatively. Many teams treated their patients until removal of drains[11, 19, 20, 26, 29, 35, 36, 46]. All antibiotics used were first- or second-generation cephalosporins. First-generation cephalosporins included cephalexin[6, 29], cephalothin[22, 23], and cefazolin[19, 42], all administered at a dose of 1–2 g perioperatively, then 1 g three times per day if continued[38]. The second-generation cephalosporin was cefuroxime, which was prescribed at a dose of 1.5–2 g[39], [47] perioperatively, then 2 g twice a day[39] if continued.

Thromboprophylaxis

Most authors recommended early ambulation[5, 10, 19, 20, 23, 30–32, 35–37, 42, 44, 47, 48] and the use of compression stockings[10, 14, 22, 26, 30, 37, 39, 42, 47]. Prophylactic anticoagulation[10, 19, 21–23, 32, 38–40, 42, 48] and the use of pneumatic compression stockings[9, 19–21, 31, 35, 36, 40, 47]

were noted in several publications (Table 7). When thromboprophylaxis was described, it was performed with low-molecular-weight enoxaparin (3000 UI twice a day[21], 4000 UI per day[38, 42, 51], or 5000 UI[23] per day) or unfractionated heparin (5000 UI per day[40]). The use of fondaparinux was mentioned in only one publication[20].

Anticoagulants were first administered 1 hour before surgery[21] or 4 hours after surgery[19]. The duration of thromboprophylaxis varied among studies: for 2 days after surgery[40], until hospital discharge[19],[21], and for 1 week[48], 2 weeks[42], and 6 weeks[39] after discharge. Nemerofsky[35] performed Doppler ultrasound before discharge to eliminate thromboembolism.

Patient satisfaction and quality of life

Only one prospective study[52] assessed quality of life (QOL) and patient satisfaction in 27 patients after circumferential body lift of the lower trunk using a validated questionnaire (WHOQOL-BREF survey for QOL and FbeK for patient satisfaction). Operated patients showed a highly significant increase in global QOL, physical and psychological health, social relationships, and environment (WHOQOL-BREF; all $p < 0.01$). The FbeK results showed significant lower scores on the “insecurity and uneasiness” scale after bodylifting ($p < 0.01$) and a greater attractiveness and self-confidence scores after surgery ($p < 0.001$).

Five studies assessed patient satisfaction using non-validated questionnaires[27, 36, 41–43]. Patient satisfaction with aesthetic outcomes

after belt lipectomy was evaluated by a 1–10 visual analog scale and showed improved results[27]. Baca[41] showed an average overall improvement to scores of 9.4/10. A similar result was observed after lower body lift with autologous augmentation, with assessment using a 1–5 scale (4.35 ± 0.63)[36]. De Runz[42] evaluated overall satisfaction (55.8% excellent results), abdomen satisfaction (55.8% excellent results), buttocks satisfaction (32.7% excellent results), and QOL (improved in 73.1% of patients). No difference in satisfaction was found between buttock auto-augmentation and non-augmentation[43]. The authors of 10 studies[9, 10, 14, 21, 22, 30, 34, 35, 40, 48] reported high or very high satisfaction from all patients, without explanation of the evaluation method.

DISCUSSION

Circumferential contouring of the lower trunk procedures were initially created to treat circumferential excess skin of the lower trunk in non-bariatric patients[4–6], and progressed to the treatment of patients who had undergone massive weight loss[9]. Massive weight loss, defined in the literature as a loss of 50% of excess weight[53], is the most appropriate indication.

In this case, excess (redundant) circumferential skin is present and cannot be corrected by abdominoplasty or simple liposuction[30]. Excess posterior skin requires belt lipectomy or lower body lift, depending on the deformation.

This review provides the first overview of circumferential body contouring of the lower trunk, and the various techniques, indications, and complications, with analysis of findings in 1,748 operated patients. The majority of published series were American and European, in connection with the prevalence of obesity on these continents.

Patients eligible for operation

Patients should have stable weight for at least 6[30] or 12[39, 44] months before surgery, ideally with BMI < 35 kg/m^2[35, 39]. More women than men underwent surgery, probably for three main reasons: the global prevalences of obesity and overweight are higher in women than in men (13.7% vs. 9.3% and 37.3% vs. 35.9%, respectively)[1]; more bariatric surgeries are performed on women[2]; and women are more concerned about their appearance[54].

Optimal preoperative assessment

Anemia screening and nutritional assessment are very important. Surgery is often hemorrhagic, and anemia should be detected and corrected preoperatively[14, 42] to avoid high transfusion rates[6]. Colwell[36] recommended a baseline hemoglobin concentration of 12 g/dl.

Post-bariatric patients often present nutritional deficiencies (iron, ferritin, hemoglobin, thiamine, 25-OH vitamin D, vitamin A, vitamin B12, zinc, selenium, and folate)[55], aggravated by low compliance (60%) with vitamin

and mineral supplementation. Such deficiencies are maximal in the first year following bariatric surgery[56] and should be corrected preoperatively to reduce surgical complications, especially wound problems[57]. Fischer[58] demonstrated that preoperative albumin levels and malnutrition were associated with increased odds of minor wound complications in all body contouring procedures. Nutritional deficiencies create biomechanical changes in the skin[59, 60] that delay wound healing.

Austin[61] demonstrated the positive impact of protein nutritional supplementation on abdominoplasty, with a decrease in wound dehiscence. We believe that the same preoperative assessment should be performed for circumferential body contouring. Nutrition should be controlled not only preoperatively, but also after surgery with protein supplementation[62].

Current trends in technique

Belt lipectomy was the first technique described in the literature[4], whereas lower body lift[6, 11, 29] is most popular. A gluteal augmentation flap[14], supplied by perforators from the superior gluteal artery, lateral sacral arteries, and lumbar artery[14, 20, 33], can be added to correct insufficient buttock projection. Colwell[36] showed that major perforators are generally situated 6–9 cm from the midline, whereas Nojima[63] placed them 10–12 cm from the midline.

Despite the effect on gluteal projection, these techniques may actually increase the complication rate[43]. We noted that gluteal fat necrosis[20, 33,

34, 36] and gluteal hypoesthesia[14, 48] were reported only in patients who were treated with auto-augmentation flaps.

The most conservative and safe procedure is probably “lipogluteoplasty”[17, 18], which uses a technique similar to that used in brachioplasties[64] and medial thigh lifts[65, 66], with skin resection just under the dermis with no undermining. It can eventually be combined with buttock augmentation techniques without flap[15–17]. Resection under the dermis after liposuction is even more conservative in terms of the blood and lymphatic systems[18, 67]. When deeper resection is performed, the use of fibrin sealant during surgery[33] and quilting sutures[20] may reduce dead spaces.

We identified no study of fat grafting into buttocks. This situation is probably due to the risk of reduced graft survival, as the patient lies on the grafted fat during the postoperative course[20].

Complications

Since the 50% complication rate described by Lockwood[6], the complications rate has decreased among published reports, with a mean of 37%. This rate is comparable to that for abdominoplasties (between 18%[68] to 40%[69]) and brachioplasties (from 20%[70, 71] to 56%[64]). It remains lower than medial thigh lifts (43–74%[72, 73]). Major complications are uncommon and the most frequent complications are minor: seroma, wound dehiscence, and scar irregularities. Wound dehiscences may be prevented by stop smoking and supplementing nutritional carencies before surgery[57]; seromas by the use of fibrin sealant during surgery[33]; quilting sutures to

reduce dead space[20]; wearing a compression garment for 6 weeks[42]. The usually reported idea is that preserving superficial fascia is essential to diminish seromas. Making a resection under the dermis after a liposuction seems even more conservative towards the blood and lymphatic system[18, 67] .Gluteal hypoesthesia and gluteal fat necrosis only occurred in patients who had a gluteal augmentation with flap.

Post bariatric patients were associated with a higher complications rate during abdominoplasties, especially healing problems[74],[75]. This was not reported during circumferential procedures[38, 42]. However this surgery was intented for massive weight loss patients, creating a selection bias.

Our review confirmed that, when combining different body contouring techniques such as lower body lift and medial thighplasty[6, 39], complication rate increases[76, 77].

Although minor complications are frequent, circumferential contouring of the lower trunk should be proposed whenever it is indicated, because the quality of life is improved[52]. In this surgery, the benefit to patients is mainly functional, not esthetic.

Antibiotic prophylaxis

The infection rate after circumferential contouring of the lower trunk was similar to that following abdominoplasty (7%[68]–8%[78]). For abdominoplasty, antibiotic prophylaxis was recommended[79, 80]. For circumferential contouring, further specific studies are necessary to assess the efficacy of antibiotic prophylaxis.

Thromboprophylaxis

Patients undergoing circumferential procedures of the lower trunk should always be considered to be at high risk of thromboembolism[81, 82]. Hatef[51] found that enoxaparin administration was associated with a decrease in deep venous thrombosis in patients undergoing circumferential abdominoplasty. For all body contouring procedures, he reported BMI > 30 kg/m^2, hormone therapy, and circumferential abdominoplasty as risk factors for thromboembolism and recommended systematic thromboprophylaxis in these cases[51]. Similar results[83] were reported among patients undergoing procedures after bariatric surgery with BMIs > 35 kg/m^2.

Based on this review, we strongly recommend chemoprophylaxis associated with early ambulation and the use of compression stockings (standard patients) or pneumatic stockings (high-risk patients). The risk of phlebitis is slightly higher[51] than for abdominoplasty, but it can be reduced by these simple measures.

The timing of administration of the first dose varied among studies, with no difference in intraoperative blood loss, postoperative bleeding, or thromboembolism[51]. Independently of the timing, chemical thromboprophylaxis was associated with increased rates of hematoma[39] and postoperative bleeding[51]. This situation explains why some authors did not administer heparin[35]. In our opinion, phlebitis poses a greater risk than does hematoma.

Methodological issues

Our review was limited in that the majority of studies included were low-evidence studies, e.g., retrospective series. Only two studies were prospective[39, 52]. Data concerning patient characteristics, operative techniques, and outcomes were reasonably well reported, even if means were often preferred to raw data; data concerning weight loss before surgery, preoperative assessment, use of liposuction, antibiotic prophylaxis, and thromboprophylaxis were poor. Populations were fairly heterogeneous, with differences in patient characteristics and operative techniques among studies. Further prospective studies should be designed using detailed data reporting and more strict inclusion criteria.

Only two studies were excluded because of language[84, 85], which reduced the language bias and rendered our review reasonably comprehensive. Other biases included publication bias and detection bias, as most study data were analyzed retrospectively.

CONCLUSION

To date, no clear guidelines exist for circumferential lower trunk contouring indications and contraindications. The popularity of these procedures will increase over the next few years, in parallel with the worldwide prevalence of obesity. Greater accuracy is required concerning preoperative assessment of patients, selected BMI ranges, and preoperative risk evaluation. To achieve this accuracy, better-quality studies are required to improve the ability to

analyze patient characteristics and outcomes. Future work will evolve in two directions: more highly defined indications established by physicians and improved information regarding surgical risks for patients.

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FIGURE LEGENDS

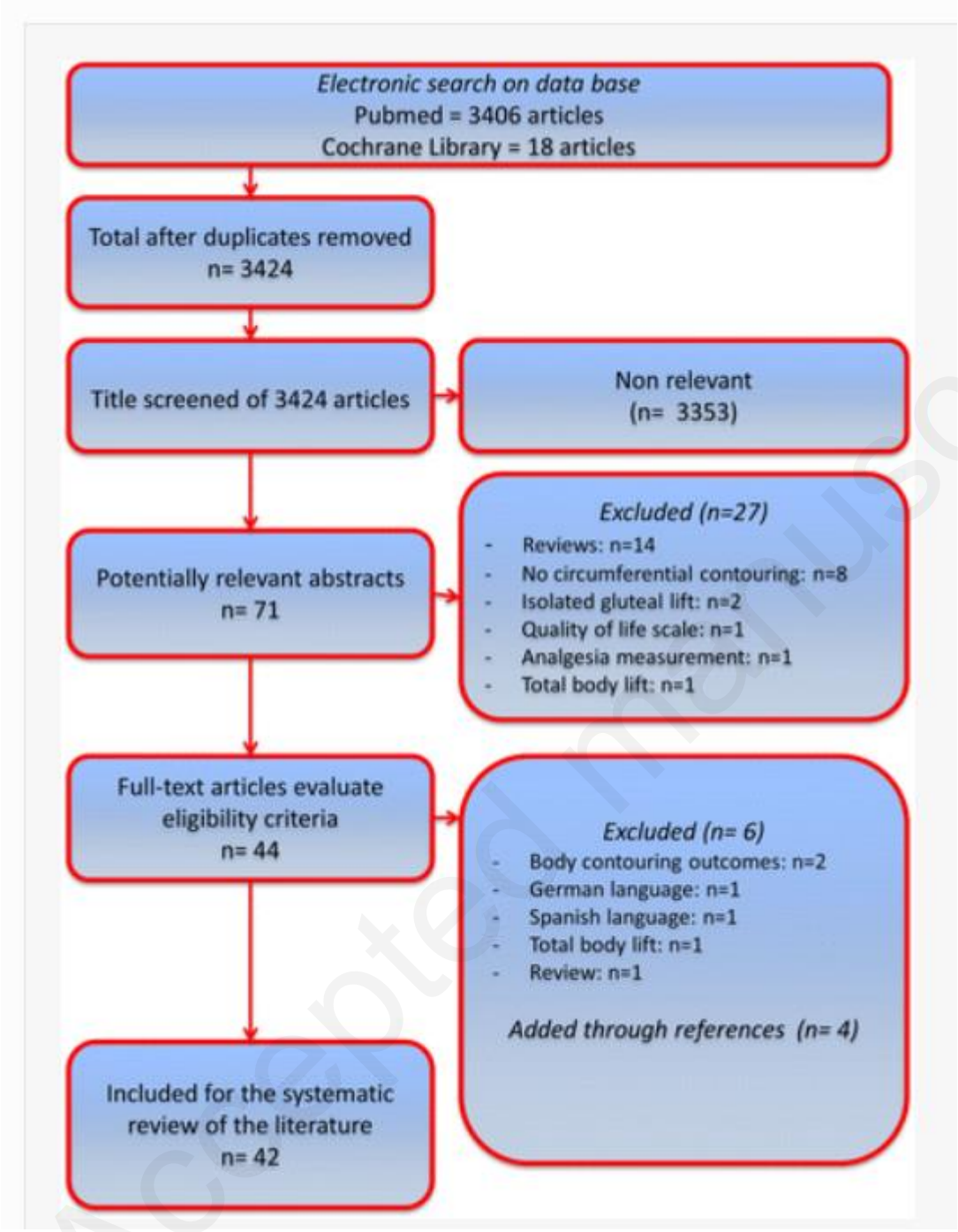

Figure 1. Prisma flow chart of the systematic review.

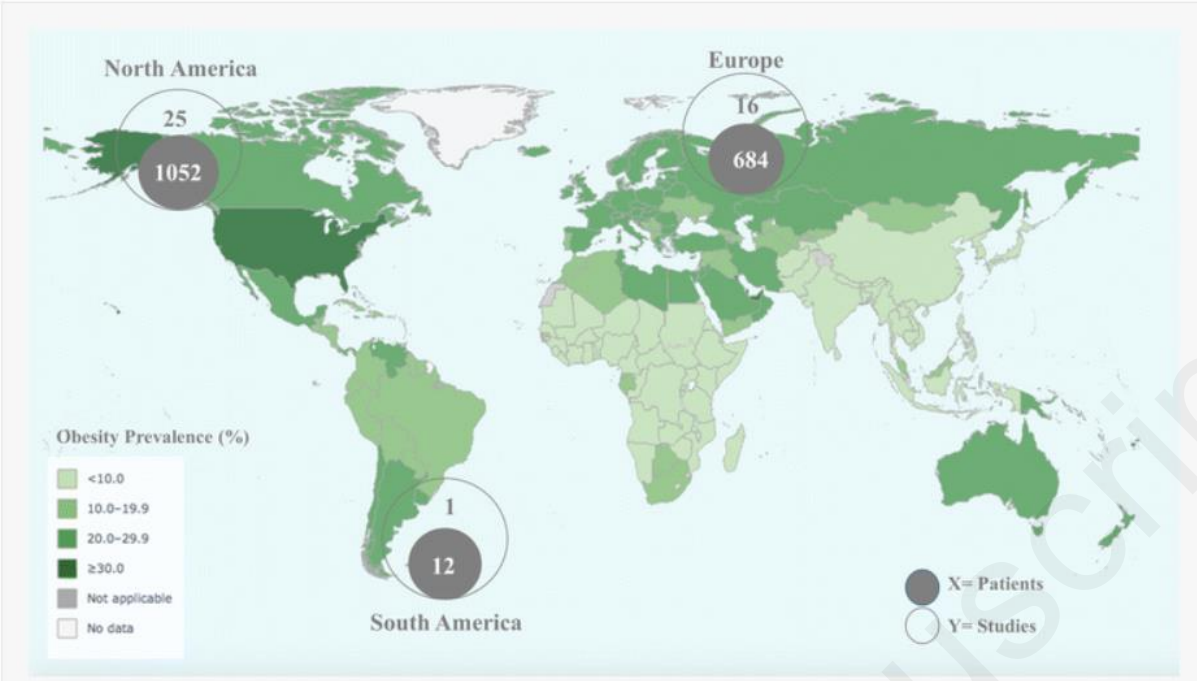

Figure 2. Obesity prevalence *(gamapserver.who.int/gho/interactive_charts/ncd/risk_factors/obesity/atlas.html)* and geographical distribution of publications.

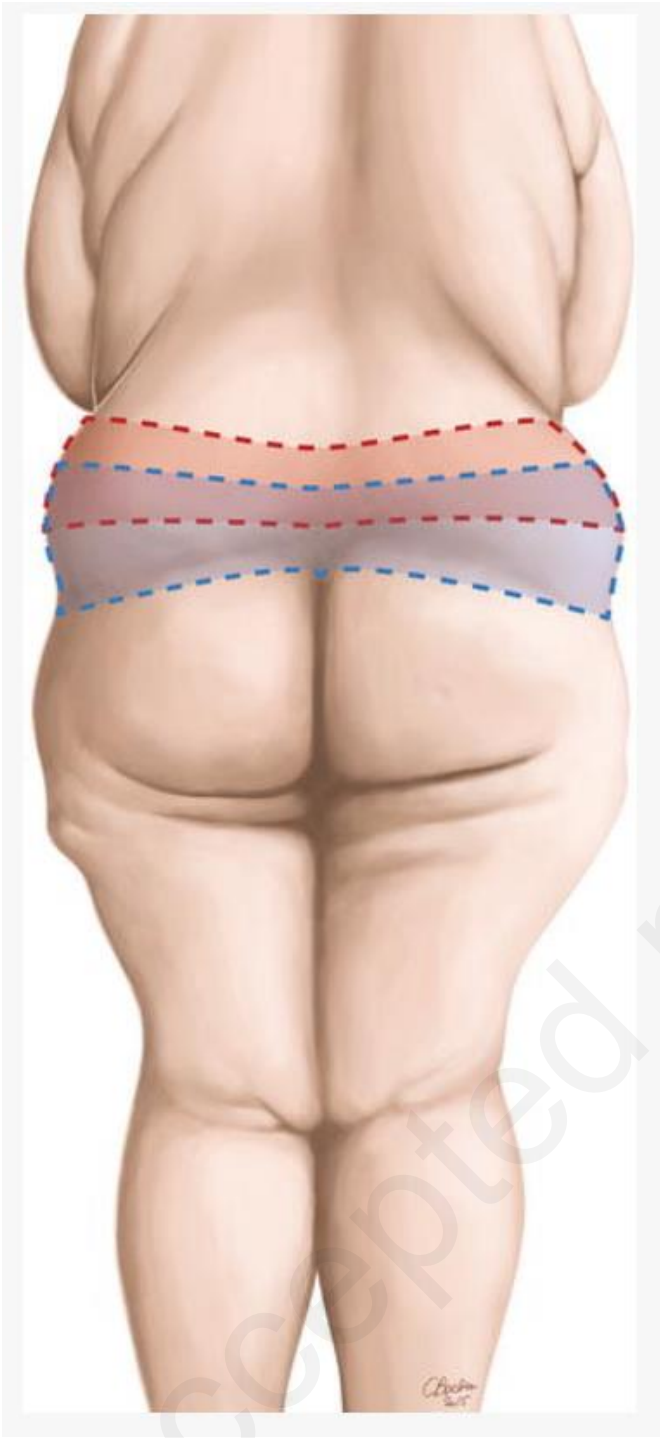

Figure 3. Skin patterns of belt lipectomy (red markings) and lower body lift (blue markings). For belt lipectomy: pattern is higher; superior resection line is drawn first at the superior margin of the flank rolls. For lower body lift: pattern is lower; inferior resection line is drawn first either inside or at the superior margin of the gluteal cleft.

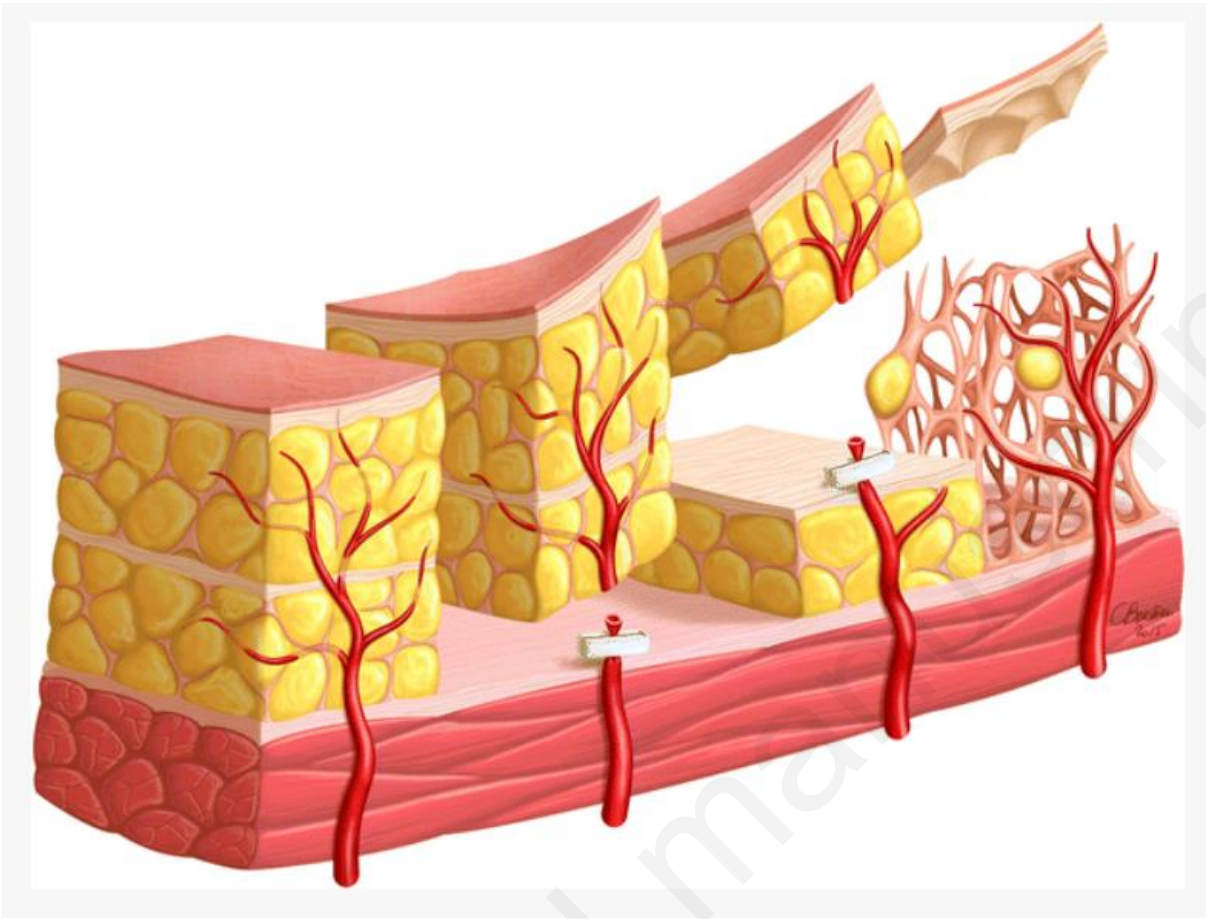

Figure 4. Different resection depths during posterior step: (1) to the muscular fascia, (2) to the superficial fascia or (3) under the dermis following liposuction of both superficial and deep fat.

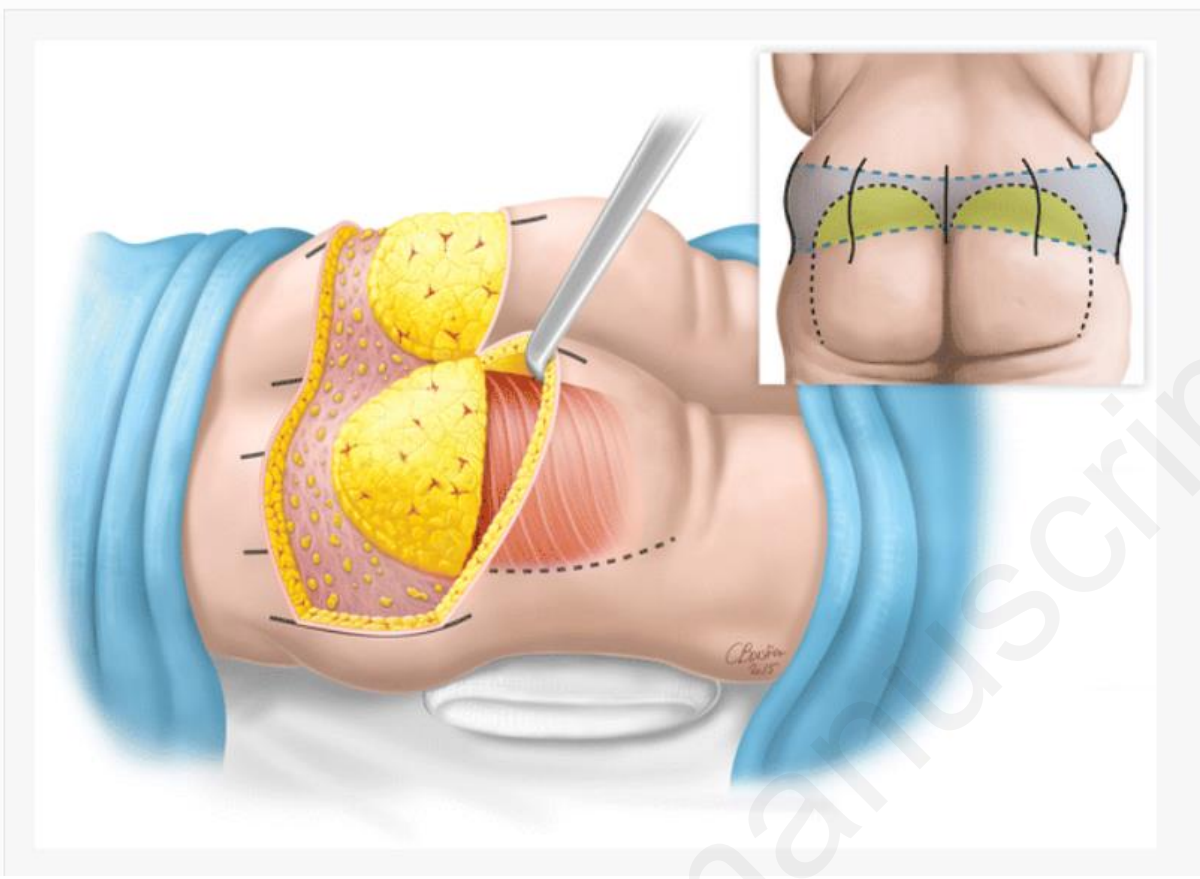

Figure 5. Technique of buttock augmentation with flap. An autologous dermal fat flap is dissected and moved down to the gluteal fold, after an undermine over the gluteus maximus muscle creating thus a “gluteal pocket”.

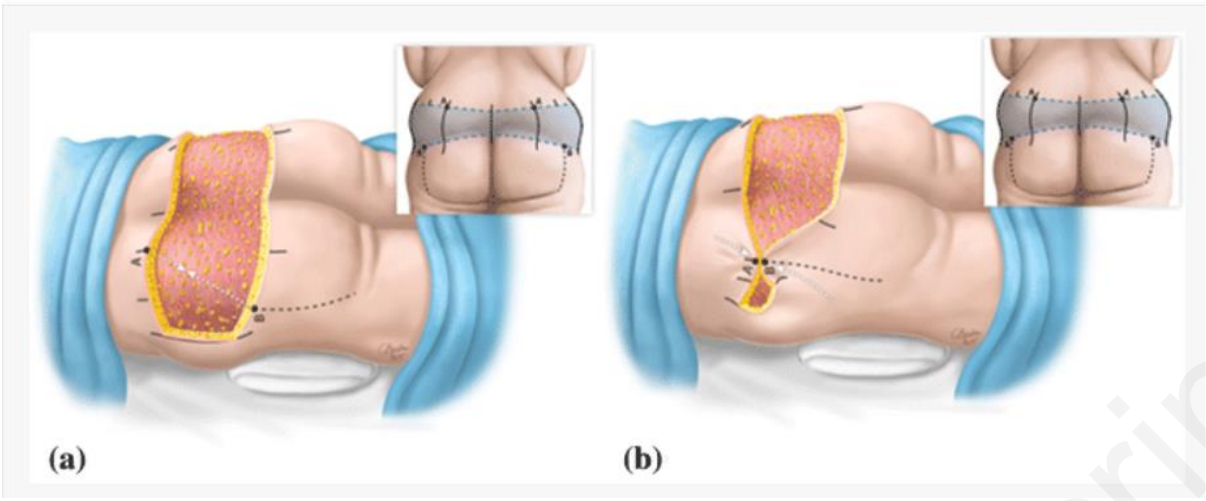

Figure 6. Technique of buttock augmentation without flap. a) Point B, located at the lateral end of the gluteal fold on the inferior resection line, is sutured to point A, located 5 cm medially to point B on the superior resection line. b) gluteal augmentation by suturing point B to point A.

Table 1

Presentation of included articles, with level of evidence

Article	Country	Study design	Evidence level	Number of included patients
Gonzalez-Ulloa [4]	Spain	Technical description	V	2
Vilain and Dubousset [5]	France	Retrospective cohort	III	150
Lockwood [6]	United States	Case Series	IV	10
Lockwood [29]	United States	Technical description	V	1
Hunstad [46]	United States	Technical description	V	1
Carwell and Horton [9]	United States	Case Series	IV	7
Van Geertruyden [10]	Belgium	Retrospective cohort	III	30
Hamra [26]	United States	Retrospective cohort	III	40
Lockwood [11]	United States	Technical description	V	2
Heddens [30]	United States	Retrospective cohort	III	32
Pascal and Le Louarn [14]	France	Retrospective cohort	III	40
Modolin et al. [22]	Brazil	Retrospective cohort	III	12
Morales Gracia [23]	Mexico	Retrospective cohort	III	39
Aly et al. [31]	United States	Retrospective cohort	III	32
Pascal and Le Louarn [32]	France	Retrospective cohort	III	100
Cormenzana and Samprón [28]	Spain	Retrospective cohort	III	20
Rohde and Gerut [33]	United States	Retrospective cohort	III	62
Van Huizum et al. [27]	Netherlands	Retrospective cohort	III	21
Sozer et al. [34]	United States	Retrospective cohort	III	20
Centeno [20]	United States	Retrospective cohort	III	21
Nemerofsky et al. [35]	United States	Retrospective	III	200

Article	Country	Study design	Evidence level	Number of included patients
		cohort		
Rohrich et al. [21]	United States	Retrospective cohort	III	151
Strauch et al. [19]	United States	Retrospective cohort	III	75
Colwell and Borud [36]	United States	Retrospective cohort	III	18
Davison et al. [49]	United States	Case Series	IV	3
Aly et al. [50]	United States	Technical description	V	0
Hatef et al. [51]	United States	Retrospective cohort	III	65
Shermak et al. [45]	United States	Retrospective cohort	III	57
Jones and Toft [47]	United Kingdom	Retrospective cohort	III	16
Dini et al. [48]	Italy	Retrospective cohort	III	41
Kolker and Lampert [37]	United States	Retrospective cohort	III	24
Vico et al. [38]	Belgium	Retrospective cohort	III	80
Koller and Hintringer [15]	Austria	Retrospective cohort	III	50
Koller and Hintringer [16]	Austria	Letter to the editor	V	1
Koller et al. [52]	Austria	Prospective cohort	II	27
Kitzinger et al. [39]	Austria	Prospective cohort	II	50
Buchanan et al. [40]	United States	Retrospective cohort	III	35
Baca et al. [41]	United States	Retrospective cohort	III	59
Aly et al. [44]	United States	Technical description	V	1
De Runz et al. [42, 64]	France	Retrospective cohort	III	55
Koller [18]	Austria	Letter to the editor	V	1
Srivastava et al. [43]	United States	Retrospective cohort	III	97

Table 2

Geographical distribution of publications and number of patients

Country of origin	Number of articles	Number of patients
United States	24	1013
Austria	5	129
France	4	345
Belgium	2	110
Spain	2	22
Italy	1	41
Mexico	1	39
Netherlands	1	21
United Kingdom	1	16
Brazil	1	12
Total	42	1748

Table 3

Patient characteristics

	Articles including data (*n*)	Median [IQR]	Mean ± 95 % CI	Min	Max
Age (years)	15	41 [40–44]	41.25 ± 2.16	18	70
Female (%)	19	88 [84–95]	88.4 ± 3.6	75	100
BMI (kg/m²)	14	28.6 [27.8–29.5]	29.2 ± 1.6	20.2	39.8
Max BMI (kg/m²)	6	50.6 [50.11–52.05]	52.96 ± 4.41	36.2	104.1
Loss of weight (kg)	9	49.6 [44–60.5]	53.31 ± 10.11	0	200
Loss of BMI (kg/m²)	7	22.2 [20.66–23.02]	21.97 ± 1.74	12	28
Time for weight loss (years)	1	2.95 [2.07–3.77]	2.96 ± 1.08	1.2	4.9

IQR inter-quartile range, *CI* confidence interval

Table 4

Indications and operative techniques

Article	Indication	Patient positioning	Operative technique	Buttock augmentation	Buttock Resection depth	Liposuction
Gonzalez-Ulloa [4]	Post pregnancy, obese, post-diet weight loss	Supine then prone	Belt lipectomy	No	Muscular fascia	No
Vilain and Dubousset [5]	Post-diet weight loss	Supine then prone	Belt lipectomy	No	Muscular fascia	No
Lockwood [6]	Truncal excess (normal weight)	Supine then twice lateral	Lower body lift	NO	Superficial Fascial	Yes
Lockwood [29]	Truncal excess (normal weight)	Supine then twice lateral	Lower body lift	No	Superficial Fascial	Yes
Hunstad [46]	Obese	Supine then prone	Belt lipectomy	No	Muscular fascia	Yes
Carwell and Horton [9]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Belt lipectomy	No	Muscular fascia	Yes
Van Geertruyden [10]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Belt lipectomy	No	Muscular fascia	Yes
Hamra [26]	Post pregnancy, massive weight loss	Supine then twice lateral	Belt lipectomy	No	Muscular fascia	Yes
Lockwood [11]	Massive weight loss	Supine then twice lateral	Lower body lift	No	Superficial Fascial	Yes
Heddens [30]	Bariatric surgery or diet	Prone then supine OR Supine then twice lateral	Belt lipectomy	No	Muscular fascia	Yes
Pascal and Le Louarn [14]	Massive weight loss	Prone then supine	Lower body lift	Autologous flap	Muscular fascia	Yes

Article	Indication	Patient positioning	Operative technique	Buttock augmentation	Buttock Resection depth	Liposuction
Modolin et al. [22]	Massive weight loss (bariatric surgery)	Prone then supine	Belt lipectomy	No	Muscular fascia	NR
Morales Gracia [23]	Overweight (0–35 kg)	Twice lateral then supine	Belt lipectomy	No	Muscular fascia	Yes
Aly et al. [31]	Massive weight loss, normal weight, overweight or obese	Prone then supine OR Supine then twice lateral	Belt lipectomy	No	Muscular fascia	Yes
Pascal and Le Louarn [32]	Massive weight loss	Prone then supine	Lower body lift	Autologous flap	Muscular fascia	yes
Cormenzana and Samprón [28]	Post pregnancy, obese or massive weight loss	NR	Belt lipectomy	No	NR	Yes
Rohde and Gerut [33]	Massive weight loss (bariatric surgery)	Supine then prone	Lower body lift	Autologous flap	Muscular fascia	NR
Van Huizum et al. [27]	Post pregnancy or massive weight loss	Supine then prone	Belt lipectomy	No	Muscular fascia	NR
Sozer et al. [34]	Massive weight loss (bariatric surgery or diet)	Twice lateral then supine	Lower body lift	Autologous flap	Muscular fascia	Yes
Centeno [20]	Massive weight loss	Prone then supine	Lower body lift	Autologous flap	Muscular fascia	NR
Nemerofsky et al. [35]	Massive weight loss (bariatric surgery or diet)	Supine then twice lateral	Lower body lift	No	Muscular fascia	Yes
Rohrich et al. [21]	Massive weight loss or truncal	Prone then supine	Belt lipectomy	No	Muscular fascia	Yes

Article	Indication	Patient positioning	Operative technique	Buttock augmentation	Buttock Resection depth	Liposuction
	excess (normal weight)					
Strauch et al. [19]	Massive weight loss (bariatric surgery)	Supine then prone	Belt lipectomy	No	Superficial Fascia	NR
Colwell and Borud [36]	Massive weight loss (bariatric surgery)	Prone then supine	Lower body lift	Autologous flap	Muscular fascia	NR
Davison et al. [49]	Massive weight loss (bariatric surgery or diet)	Supine then twice lateral	Belt lipectomy	No	Muscular fascia	NR
Aly et al. [50]	NR	Supine then twice lateral	Belt lipectomy	No	Superficial or muscular fascia	Yes
Hatef et al. [51]	NR	NR	Lower body lift or belt Lipectomy	NR	NR	NR
Shermak et al. [45]	Massive weight loss	NR	Lower body lift	NR	NR	NR
Jones and Toft [47]	Massive weight loss (bariatric surgery or diet)	Twice lateral then supine	Lower body lift	No	Superficial Fascia	Yes
Dini et al. [48]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Lower body lift	Autologous flap	Muscular fascia	Yes
Kolker and Lampert [37]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Lower body lift	No	Muscular fascia	Yes
Vico et al. [38]	Massive weight loss (bariatric	Prone then supine	Lower body lift	No	Muscular fascia	NR

Article	Indication	Patient positioning	Operative technique	Buttock augmentation	Buttock Resection depth	Liposuction
	surgery or diet)					
Koller and Hintringer [15]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Lower bodylift	Without flap	Superficial Fascia	NR
Koller and Hintringer [16]	NR	Prone then supine	Lower body lift	Without flap	Superficial Fascia	NR
Koller et al. [52]	Massive weight loss (bariatric surgery)	Prone then supine	Lower body lift	NR	Superficial Fascia	NR
Kitzinger et al. [39]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Lower body lift	No	Superficial Fascia	NR
Buchanan et al. [40]	Massive weight loss (bariatric surgery or diet)	Supine then prone	Lower body lift	No	Muscular fascia	Yes
Baca et al. [41]	Non post-bariatric surgery	NR	Lower body lift	NR	NR	Yes
Aly et al. [44]	massive weight loss; normal weight or overweight	Supine then twice lateral	Belt lipectomy	No	Superficial or muscular fascia	Yes
De Runz et al. [42, 64]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Lower body lift	Autologous flap	Muscular fascia	Yes
Koller [18]	Massive weight loss	Prone then supine	Lower body lift	No	Skin-only resection	Yes
Srivastava et al. [43]	Massive weight loss (bariatric surgery or diet)	Prone then supine	Lower body lift	±Autologous flap	Muscular fascia	NR

NR not reported

Operative technique: techniques were classified as «Lower body lift» when the scar was situated at the bikini-line, as «Belt lipectomy» when the scar was situated at the waistline

Table 5

Outcomes and complications

	Articles including data (*n*)	Median [IQR]	Mean ± 95 % CI	Min	Max
Outcomes					
Resection weight (kg)	10	3.76 [3.45–4.45]	3.89 ± 0.7	0.69	15
Lipoaspirate volume (L)	7	1.68 [1.27–2.04]	1.87 ± 0.79	0.45	8.45
Operative time (min)	14	261 [222.5–306]	261.73 ± 31.72	79	654
Blood loss (L)	5	0.49 [0.46–0.63]	0.56 ± 0.24	0.2	1.9
Patients transfused (%)	15	13.75 [0–22]	21 ± 14	12.5	100
Length of stay (days)	11	3.5 [2.1–7.4]	4.73 ± 1.97	0	32
Complications					
Overall complications (%)	17	36.55 [26.63–45.65]	35.01 ± 7.66		70
Overall Revision rate (%)	22	6.25 [3.2–13.9]	10.42 ± 4.33		33
Revision rate for aesthetic purpose (%)	21	0 [0–5.75]	4.34 ± 3.22		30
Revision rate for non-aesthetic purpose (%)	21	3.5 [0.25–6]	5.82 ± 3.47		17
Wound dehiscence (%)	27	13.51 [9.38–22.5]	19.54 ± 6.81		68
Skin necrosis (%)	27	0 [0–2]	1.51 ± 0.88		10
Infection/abcess (%)	27	1.82 [0–8]	7.41 ± 5.59		60
Hematoma (%)	27	0 [0–2]	1.42 ± 0.88		10
Seroma (%)	28	9.45 [4.76–24.01]	14.46 ± 4.78		46
Scar irregularities (%)	12	11.42 [3.01–17.59]	12.59 ± 6.95		41
Thromboembolism (%)	28	0 [0–1.70]	1.53 ± 1.20		13

IQR inter-quartile range, *CI* confidence interval

Table 6

Antibiotic prophylaxis

Article	Antibiotic prophylaxis	Pre-operative	Intra-operative	Post-operative	Molecule	Posology
Gonzalez-Ulloa [4]	NR	NR	NR	NR	NR	NR
Vilain and Dubousset [5]	Yes	No	No	Yes	Penicillin	NR
Lockwood [6]	Yes	NR	NR	NR	Cephalexin (C1G)	NR
Lockwood [29]	Yes	NR	NR	Yes	Cephalexin (C1G)	NR
Hunstad [46]	Yes	NR	NR	Yes	NR	NR
Carwell and Horton [9]	NR	NR	NR	NR	NR	NR
Van Geertruyden [10]	Yes	No	Yes	No	NR	NR
Hamra [26]	Yes	NR	NR	Yes	NR	NR
Lockwood [11]	Yes	Yes	Yes	Yes	NR	NR
Heddens [30]	NR	NR	NR	NR	NR	NR
Pascal and Le Louarn [14]	Yes	No	Yes	Yes	NR	NR
Modolin et al. [22]	Yes	No	Yes	No	Cephalothin (C1G)	2 g intra-operatively
Morales Gracia [23]	Yes	No	Yes	No	Cephalothin (C1G)	1 g intra-operatively
Aly et al. [31]	NR	NR	NR	NR	NR	NR
Pascal and Le Louarn [32]	Yes	No	Yes	Yes	NR	NR
Cormenzana and Samprón [28]	NR	NR	NR	NR	NR	NR
Rohde and Gerut [33]	NR	NR	NR	NR	NR	NR
Van Huizum et al. [27]	NR	NR	NR	NR	NR	NR
Sozer et al. [34]	NR	NR	NR	NR	NR	NR
Centeno [20]	Yes	No	Yes	Yes	NR	NR
Nemerofsky et al. [35]	Yes	NR	NR	Yes	NR	NR

Article	Antibiotic prophylaxis	Pre-operative	Intra-operative	Post-operative	Molecule	Posology
Rohrich et al. [21]	Yes	Yes	NR	NR	NR	NR
Strauch et al. [19]	Yes	No	Yes	Yes	Cefazolin (C1G)	1 g intra-operatively
Colwell and Borud [36]	Yes	No	Yes	Yes	NR	NR
Davison et al. [49]	NR	NR	NR	NR	NR	NR
Aly et al. [50]	NR	NR	NR	NR	NR	NR
Hatef et al. [51]	NR	NR	NR	NR	NR	NR
Shermak et al. [45]	NR	NR	NR	NR	NR	NR
Jones and Toft [47]	Yes	No	Yes	Yes	Cefuroxime (C2G)	1,5 g intra-operatively
Dini et al. [48]	Yes	No	Yes	Yes	NR	NR
Kolker and Lampert [37]	NR	NR	NR	NR	NR	NR
Vico et al. [38]	Yes	No	Yes	Yes	Cefazolin (C1G)	1 g intra-operatively, 1 g ×3/day during 24 h after surgery
Koller and Hintringer [15]	NR	NR	NR	NR	NR	NR
Koller and Hintringer [16]	NR	NR	NR	NR	NR	NR
Koller et al. [52]	NR	NR	NR	NR	NR	NR
Kitzinger et al. [39]	Yes	No	Yes	Yes	Cefuroxime (C2G)	2 g intra-operatively, 2g × 2/day during 3 days after surgery
Buchanan et al. [40]	NR	NR	NR	NR	NR	NR
Baca et al. [41]	NR	NR	NR	NR	NR	NR
Aly et al. [44]	NR	NR	NR	NR	NR	NR
De Runz et al. [42, 64]	Yes	No	Yes	No	Cefazolin (C1G)	NR

Article	Antibiotic prophylaxis	Pre-operative	Intra-operative	Post-operative	Molecule	Posology
Koller [18]	NR	NR	NR	NR	NR	NR
Srivastava et al. [43]	NR	NR	NR	NR	NR	NR

NR not reported, *C1G* first-generation cephalosporin, *C2G* second-generation cephalosporin

Table 7

Thrombo-prophylaxis

Article	Early deambulation	Compression stockings	Pneumatic stockings	Chemioprophylaxis	Molecule
Gonzalez-Ulloa [4]	NR	NR	NR	NR	
Vilain and Dubousset [5]	Yes	NR	NR	NR	
Lockwood [6]	NR	NR	NR	NR	
Lockwood [29]	NR	NR	NR	NR	
Hunstad [46]	NR	NR	NR	NR	
Carwell and Horton [9]	NR	No	Yes	No	
Van Geertruyden [10]	Yes	Yes	No	Yes	LMWH
Hamra [26]	NR	Yes	No	No	
Lockwood [11]	NR	NR	NR	NR	
Heddens [30]	Yes	Yes	No	No	
Pascal and Le Louarn [14]	Yes	Yes	No	Yes	LMWH
Modolin et al. [22]	NR	Yes	No	Yes	LMWH
Morales Gracia [23]	Yes	NR	NR	Yes	UH (5000UI/day)
Aly et al. [31]	Yes	No	Yes	±	UH
Pascal and Le Louarn [32]	Yes	Yes	No	Yes	LMWH
Cormenzana and Samprón [28]	NR	NR	NR	NR	
Rohde and Gerut [33]	NR	NR	NR	NR	
Van Huizum	NR	NR	NR	NR	

Article	Early deambulation	Compression stockings	Pneumatic stockings	Chemioprophylaxis	Molecule
et al. [27]					
Sozer et al. [34]	NR	NR	NR	NR	
Centeno [20]	Yes	No	Yes	±	LMWH or Fondaparinux
Nemerofsky et al. [35]	Yes	No	Yes	No	
Rohrich et al. [21]	Yes	No	Yes	Yes	LMWH (Enoxaparin 3000UIx2/day) until hospital discharge
Strauch et al. [19]	Yes	No	Yes	Yes	LMWH until hospital discharge
Colwell and Borud [36]	Yes	No	Yes	No	
Davison et al. [49]	NR	NR	NR	NR	
Aly et al. [50]	NR	NR	NR	NR	
Hatef et al. [51]	NR	NR	NR	±	LMWH
Shermak et al. [45]	NR	NR	NR	NR	
Jones and Toft [47]	Yes	No	Yes	No	
Dini et al. [48]	Yes	NR	NR	Yes	LMWH for 1 week after hospital discharge
Kolker and Lampert [37]	Yes	Yes	No	No	
Vico et al. [38]	NR	NR	NR	Yes	LMWH (Enoxaparin 4000UI/day)
Koller and Hintringer [15]	NR	NR	NR	NR	
Koller and Hintringer [16]	NR	NR	NR	NR	
Koller et al.	NR	NR	NR	NR	

Article	Early deambulation	Compression stockings	Pneumatic stockings	Chemioprophylaxis	Molecule
[52]					
Kitzinger et al. [39]	NR	Yes	No	Yes	LMWH for 6 weeks after hospital discharge
Buchanan et al. [40]	NR	No	Yes	Yes	UH (5000 UI/day) or LMWH (Enoxaparin 4000 UI/day) for 2 days
Baca et al. [41]	NR	NR	NR	NR	
Aly et al. [44]	Yes	NR	NR	NR	
De Runz et al. [42, 64]	Yes	Yes	No	Yes	LMWH (Enoxaparin 4000 UI/day) for 2 weeks after hospital discharge
Koller [18]	NR	NR	NR	NR	
Srivastava et al. [43]	NR	NR	NR	NR	

NR not reported, *LMWH* low molecular weight heparin, *UH* unfractionated heparin