



Effectiveness and Role of Using Hyaluronic Acid Injections for Gluteal Augmentation: A Comprehensive Systematic Review of Techniques and Outcomes



Hatan Mortada^{1,2} · Danah Alkadi³ · Hazem Saqr^{4,11} · Faris Sultan⁵ ·
Batool Alturaiki⁶ · Saad Alrobaiea⁷ · Hattan A. Aljaaly⁸ · Khalid Arab⁹ ·
Amr Youssef Arkoubi¹⁰

Received: 17 March 2023 / Accepted: 8 June 2023 / Published online: 5 July 2023

© Springer Science+Business Media, LLC, part of Springer Nature and International Society of Aesthetic Plastic Surgery 2023

Abstract

Introduction There has been a rapid increase in the number of patients undergoing non-surgical gluteal augmentation in recent years, leading to an increase in the number of articles in the literature regarding the use of hyaluronic acid (HA) for gluteal augmentation. No systematic review has been published on the effectiveness of HA for gluteal augmentation. This study aimed to provide a

comprehensive review regarding the effectiveness and role of using HA for gluteal augmentation.

Methods This review was conducted according to the PRISMA guidelines for reporting systematic reviews and meta-analyses. We conducted a search across MEDLINE, EMBASE, Cochrane, and Google Scholar, using the following search keywords: gluteus, buttocks, gluteoplasty, gluteal augmentation, hyaluronic acid, and filler.

✉ Hatan Mortada
Hatanmortada@gmail.com

Danah Alkadi
Dana.alkady@gmail.com

Hazem Saqr
hazemmsaqr@gmail.com

Faris Sultan
Farisasultan@hotmail.com

Batool Alturaiki
Batool.alturaiki99@gmail.com

Saad Alrobaiea
alrobaiea.saad@gmail.com

Hattan A. Aljaaly
hattanaljaaly@gmail.com

Khalid Arab
arab.khalid@gmail.com

Amr Youssef Arkoubi
ayarkoubi@imamu.edu.sa

¹ Division of Plastic Surgery, Department of Surgery, King Saud University Medical City, King Saud University, Riyadh, Saudi Arabia

² Department of Plastic Surgery and Burn Unit, King Saud Medical City, Riyadh, Saudi Arabia

³ Department of Surgery, College of Medicine, King Saud University, Riyadh, Saudi Arabia

⁴ School of Medicine, Newgiza University (NGU), Giza, Egypt

⁵ King Saud bin Abdulaziz University for Health Sciences, Jeddah, Saudi Arabia

⁶ College of Medicine, King Faisal University, Hafouf, Saudi Arabia

⁷ Department of Plastic Surgery and Burn Unit, Security Forces Hospital, Riyadh, Saudi Arabia

⁸ Division of Plastic Surgery, Department of Surgery, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia

⁹ Division of Plastic Surgery, Department of Surgery, College of Medicine, King Saud University, Riyadh, Saudi Arabia

¹⁰ Department of Surgery, College of Medicine, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia

¹¹ Department of Plastic and Reconstructive Surgery, University of Pittsburgh, Pittsburgh, USA

Results Ten articles published between 2013 and 2022 that included 168 patients. The estimated duration of product effectiveness is 16.16 months. Most studies showed statistically significant improvements in patients' satisfaction. Mean volume of HA injected for optimal gluteal fat augmentation was 206.71 ml. Of included studies, two reported major complications, five patients experienced bruising and erythema as minor complications, five patients experienced effusion and inflammation at the injection site, three patients experienced gel dislocation, and one patient experienced irregular contours.

Conclusions Based on our findings, HA is a predictable method for gluteal augmentation. Patients were satisfied with their outcomes. Despite gluteal augmentation with HA having a modest complication rate, it can still involve serious complications such as diffuse alveolar hemorrhage and death. There is a need for further research in a randomized control trial.

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 the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Gluteal · Gluteal augmentation · Hyaluronic acid · Filler · HA filler · Non-surgical procedure · Outcome · Complications

Introduction

For the last 40 years, facial and body filler injection has been a popular choice for the restoration of volume lost by natural aging or for contouring purposes. Initially, bovine fillers were used, which were popular until the introduction of hyaluronic acid (HA) as a filler option [1]. HA is a high-molecular-weight polysaccharide, which is widely distributed in the extracellular matrix of the connective tissues. Since it was first isolated by German pharmacist Karl Meyer in 1934, HA has been used by the cosmetics industry since the late 90s. Although there are many options when it comes to injectable fillers, statistics published in 2008 by the *American Society for Aesthetic Plastic Surgery* showed that HA fillers were the most commonly used injectable substance [2]. HA may be animal-derived or non-animal-derived and may differ in their concentration, particle size, cross-link density, duration, and the presence of lidocaine [3]. Due to its highly anionic nature, HA attracts water and causes the injected area to swell, thereby creating structural support and volume [3].

The technique of injection depends on the site of injection and the nature of the problem to be addressed [4]. Popular areas of injection include the nasolabial folds, lips,

dorsum of the hands, and the gluteal region. Adverse effects associated with gluteal injection with HA include pain, bruising, redness, itching, and swelling, most of which are self-limited or may be mitigated with the use of lidocaine [5]. Additionally, rare side effects include infection, granulomatous foreign body, and tissue necrosis [6]. When tissue necrosis due to the injection of HA into an artery is suspected, it may be treated with hyaluronidase to dissolve the injected HA [7].

Several studies have been published on the role and efficacy of using HA for gluteal augmentation. An article published in the *Aesthetic Plastic Surgery Journal* reported positive results for patients who received HA injections for gluteal augmentation, without any significant complications or adverse events [8]. In another study published in 2022, HA injections were effective and well tolerated, with a high degree of patient satisfaction [9]. The use of HA for gluteal augmentation is a relatively new technique, and further research is required to fully understand its long-term safety and efficacy. Prior to undergoing any cosmetic procedure, patients should be consulted about the risks and benefits.

Existing studies examined alternative techniques for gluteal augmentation, including silicone and autologous fat grafting [10, 11], but no study has examined clinical and patient-reported outcomes, patient satisfaction, and complications related to gluteal injections with HA. The purpose of this review was to provide the plastic surgery literature with a comprehensive, standardized review of all studies involving the role and effectiveness of using HA injection for gluteal augmentation.

Methods and Materials

Literature Search

The review was conducted in accordance with the protocol for the International Prospective Register of Systematic Reviews (PROSPERO) (ID: CRD42022382798) [12], as well as the Cochrane review methods [13]. Literature searches were conducted in December 2022 using the following electronic databases: MEDLINE, EMBASE, Cochrane, and Google Scholar, without time frame limitation. The search algorithms used were “gluteal,” “gluteus,” “Brazilian buttock,” “buttocks,” “gluteoplasty,” “gluteal augmentation,” “buttock augmentation,” and “hyaluronic acid” or “filler.”

Study Selection

Four investigators reviewed the titles and abstracts of the included articles and selected relevant studies for a full review. Articles were extracted from the databases and screened using Rayyan (<https://www.rayyan.ai/>) [14]. In cases where the title and abstract did not provide sufficient information, the full text was also reviewed. The inclusion criteria for the systematic review were: (1) publication without time frame limitations in December 2022, (2) all patients underwent gluteal augmentation with HA, (3) study population included adults over 18 years old, (4) studies were in English, and (5) the type of articles was prospective cohort, retrospective, cross-sectional, randomized controlled trials, case reports, or case series. A clinical outcome was reported, and HA filler was used as the injection of choice. The following criteria excluded the analysis: (1) articles in a language other than English, (2) articles that used material other than HA filler for gluteal augmentation, (3) articles for non-gluteal augmentation patients, (4) articles that used an improper method (systematic review, economic analyses, animal studies, cadaver studies, narrative review, and editorials), and (5) articles that did not report the interested outcomes. The articles were retrieved and screened by four independent investigators, and disagreements were resolved by a fifth investigator.

Screening and Data Extraction

Each report was retrieved by one investigator and assessed blindly by two other investigators. Four authors (DA, HS, FS, and BA) independently screened the included criteria and extracted the following information: year of publication, journal name, study design, author names, country, first author's last name, number of patients, number of patients HA, age range, age in months, sex, comorbidities, BMI, care centers, duration of product effectiveness, injection technique, injection material, the primary specialty of the injecting physician, injection equipment and protocol, use of botulinum toxin, location of injection, the indication of injection, injection plane, the quantity of HA, type of anesthesia, antibiotics, frequency of injection, patient satisfaction, major complications, minor complications, number of complications, study strengths, study weaknesses, clinical recommendations, and significant outcomes. A fifth author assessed any concerns that could not be resolved.

Quality Assessment and Risk of Bias

The authors evaluated the quality of the case reports and case series that were included and assessed the risk of bias

by using the methodological quality and synthesis of case series and case reports tool [15]. The Newcastle–Ottawa Scale, which rates the methodological quality using eight items divided into four categories (selection, ascertainment, causality, and reporting), was used [16]. The scale ranges from a score of 0 to 9, with a score of 7 to 9 indicating a high-quality study with a low risk of bias, a score of 4 to 6 indicating a fair-quality study with a moderate risk, and a score of 0 to 3 indicating a low-quality study with the greatest risk of bias. We evaluated all the articles included in the review according to the American Society of Plastic Surgeons' level of evidence and grading recommendations [17].

Statistical Analysis of Data

Despite performing a basic descriptive statistical analysis, a meta-analysis was not possible due to the heterogeneity of the included articles and the lack of data in a format suitable for meta-analysis.

Results

Overview of the Literature

The authors identified 1177 articles at the beginning, including 106 articles in MEDLINE, 112 articles in Embase, 200 articles in Google Scholar, and 759 articles in the Cochrane Library. The title and abstract of 920 unique studies were screened after removing duplicate articles. Following the full-text screening of 18 articles, ten articles met our inclusion/exclusion criteria [8, 18–26]. A number of articles were excluded for various reasons, including the lack of full text in two, the use of non-HA material in three, no outcome of interest in two, and the use of a non-English study in one. The studies included in this review were all published between 2013 and 2022. Table 1 summarizes the studies reporting gluteal augmentation with HA. We included two case reports, one case series, five prospective cohort studies, as well as two retrospective studies. There were no randomized clinical trials included in the included studies. The studies were conducted in different parts of the world, with six being conducted in Europe, two in the Middle East, one from Brazil, and one from Malaysia, in Fig. 1. In Fig. 2, an overview of the PRISMA process for conducting a systematic review is shown.

Clinical Characteristics of Patients

A total of 168 patients were reviewed across all studies, with 147 patients receiving HA filler for gluteal augmentation. A description of the clinical characteristics of the

Table 1 Studies reporting gluteal augmentation using HA

Authors	Name of Journal Published In	Study Design	Country	Age	Male/ female	BMI	Level of evidence
Salahia and Dar [24]	European Journal of Medical and Health Sciences	Prospective study	UAE	29–45	0/2	N/A	II
Santorelli et al. [8]	Aesth Plast Surg	Retrospective study	Italy	19–57	0/43	less than or equal to 30	IV
Camenisch et al. [23]	Plastic and reconstructive surgery	Prospective study	Sweden	45.3 ± 7.4	1/7	22.7 ± 2.3	IV
De Meyere et al. [22]	Aesthetic plastic surgery	Prospective study	Belgium, Spain, and Sweden	20.1–64.5	4/57	18.6–27.9	IV
Glancey [26]	Case Reports and Reviews: Open Access	Case series	UK	28	0/1	N/A	IV
Che Ani et al. [20]	Monaldi Archives for Chest Disease	Case report	Malaysia	38	0/1	N/A	V
Claude et al. [25]	Plastic and Reconstructive Surgery - Global Open	Prospective study	France	39.9–50.8	5/5	17.5–25.6	V
Lourenço et al. [19]	Journal of Cosmetic Dermatology	Retrospective study	Brazil	N/A	N/A	N/A	V
El-Khalawany et al. [18]	Annals of Diagnostic Pathology	Prospective study	Egypt	31–57	0/38	N/A	V
Uz et al. [21]	t. Ulus Travma Acil Cerrahi Derg	Case report	Turkey	46	0/1	N/A	V

studies included is provided in Table 2. In one study, the number of patients assessed was not specified [19]. The average age of the patients was 37.3, ranging from 20 to 64 years old. In regard to gender, ten were males, and 155 were females (92.26%). All of the patients were without comorbidities, except for two patients who had peripheral facial paralysis [21], and one patient who had HIV [25]. In all the included studies, BMI ranged between 17.5 and 30 kg/m². As for the procedure setting, four studies were conducted in a private clinic, two studies were multicenter, and two studies were in a university hospital. The rest were conducted in HIV clinics and community hospitals. The estimated duration of product effectiveness ranged from 4 to more than 24 months, with a mean of 16.16 months. Only five studies described the technique used to augment the gluteus by HA, including the multilayer technique ($n = 1$), multiple tunneling techniques ($n = 2$), and fanning injection ($n = 2$). All studies included in this review used HA for gluteal augmentation. Among these, three studies utilized Macrolane VRF 30, two studies employed Macromolecular HA gel, one study utilized Eikonha gel, and four studies did not report the type of HA used. The quantities of HA administered varied among the included studies. However, eight of the ten studies provided information on the total quantity of HA injected, while only six reported the quantities injected per side. Table 3 outlines the quantities injected per side or in total for each study.

Only two studies described the specialty of the injecting specialist, one by a plastic surgeon [24] and the other by a “beauty center specialist” [21]. Across the studies, the cannula size used ranged from 12 G to 18 G, with the majority of studies ($n = 4$) utilizing 12G needles as their choice for HA injections. In one study, Salehia et al. used a fine cannula (2 mm in diameter and 150 mm in length). As for the injection plane, the majority of studies injected HA into deep subcutaneous fat and above the muscle fascia. A total ranging from 100 to 420 ml of HA was injected for optimal gluteal fat augmentation, with a mean of 206.71 ml. In a single study by Lourenco et al, he injected 20 ml per session until optimal results were achieved for the entire buttock [19]. All the studies performed their HA gluteal augmentation under local anesthesia using lidocaine 0.5% or 1%. In two studies, lidocaine was combined with adrenaline [22, 23]. A total of eight of the ten articles included in this review used antibiotics postoperatively, with flucloxacillin being reported in two studies [22, 23], while augmentin was used in a single study [24]. Patients’ satisfaction was assessed using various scales and instruments. In most of the studies, there was a statistically significant improvement in the scale used and overall patient satisfaction. Among the included studies, two reported major complications following gluteal augmentation with HA. Seven studies reported no significant adverse events, and one study did not report on major



Fig. 1 An overview of the geographic distribution of articles included on gluteal HA augmentation worldwide

complications. The reported major complications included one case that developed diffuse alveolar hemorrhage, which subsequently progressed to acute myocardial infarction [20], and another case that resulted in death due to fat embolism syndrome (FES) [21]. In regard to minor complications, 5 patients experienced bruising and erythema, 5 had effusion and inflammation at the injection site, 3 patients experienced dislocation of the gel, and 1 patient experienced contour irregularities. Reported follow-up duration in all included studies ranged from 4 days to 24 months. An overview of the included articles on gluteal HA augmentation and their strengths, weaknesses, and clinical recommendations is provided in Table 4.

Quality Assessment and Risk of Bias

Two reviewers independently assessed the risk of bias. The methodological quality and synthesis assessment tool was based on eight components that fall into four domains: selection, ascertainment, causation, and reporting [15]. The findings of both reviewers were the same regardless of whether the material appeared to be biased, in Table 5. Retrospective and prospective cohort studies used the

Newcastle–Ottawa Scale for bias assessment. Using the Newcastle–Ottawa scale, case–control and cohort studies scored 7 out of 9, indicating a high level of quality (Table 6). According to the level of evidence and grading recommendations of the American Society of Plastic Surgery, among the included studies, one study had a level II, four studies had a level IV, and five studies had a level V of evidence (Table 1) [17].

Analyzing quantitative data

Quantitative meta-analyses were not possible due to the disparities in methodologies, interventions, insufficient extracted data, and outcomes measured.

Discussion

This review aimed to investigate the overall role of HA injection for gluteal augmentation in all relevant published literature to date. In line with our study's results of 147 patients who underwent gluteal augmentation with HA injection, all patients reported significantly improved

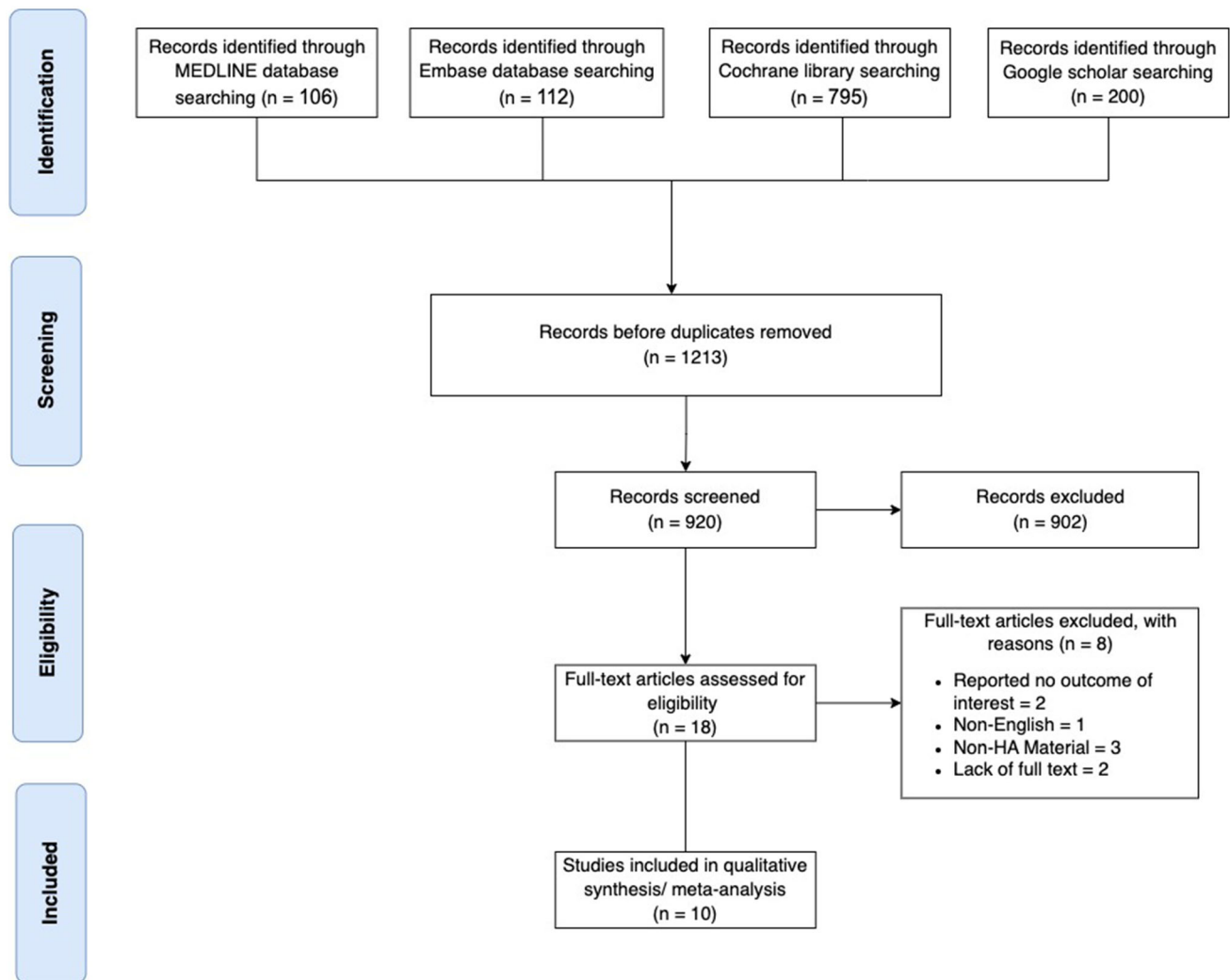


Fig. 2 This diagram illustrates the PRISMA chart used for conducting this systematic review

satisfaction scores, modest efficacy with an estimated product effectiveness ranging for up to more than 24 months and a mean of 16.16 months as well as modest index of safety with a low incidence of minor complications and a rare occurrence of major ones. Reported minor complications were erythema, bruising, injection site inflammation, effusion, and gel dislocation with associated contour irregularities which are all possible complications to any injection procedure with little potential for progressing into more significant major events [27]. Additionally, the incidence of serious complications was uncommon and was reported in two cases where one was diagnosed with diffuse alveolar hemorrhage and acute myocardial infarction that led to death and another which developed fat embolism syndrome (FES) [20, 21]. Both studies were not able to ascertain the occurrence of these complications as a direct result of HA injections, and they were all correlations that were deduced from the sequence

of events that occurred post-injection and not due to solid clinical exclusion of all possible causes in these two cases. Additionally, it is noteworthy to consider that in the two cases who developed major complications, HA injections were administered by non-physicians in both cases.

Concurrent with our study findings, showing the high effectiveness of HA injections in improving patients' aesthetic satisfaction lasting for more than 24 months post-treatment, a prospective, multicenter study by De Meyere et al. [22] demonstrated similar findings and that patients' satisfaction had remained sustainably high after 24 months of follow-up regardless of the degradable and non-permanent nature of HA.

HA injections had also demonstrated a relatively safe profile for administration in the gluteal region as evidenced by adverse events reporting in the studies conducted by De Meyere et al. and Camenisch et al. [22, 23]. Additionally, minor complications are already established and

Table 2 A description of the clinical characteristics of the studies included

Authors	Duration of product effectiveness	Injection technique	Material used	Injection equipment used	Injection protocol	Location of injection	Injection plane	Quantity (Units)	Type of anesthesia	Frequency of injection	Follow-up duration
Salahia and Dar [24]	> 24 months	Fanning injection technique	Eikonha (HA gel) (AK Pharma, Inc., USA.)	Fine cannula (2mm dia./150mm len.)	Site marking, disinfection, local anesthesia, injection administration, post-injection massage from top to bottom for spreading HA, immediate change/reshaping of buttocks according to the procedure. Following the massage, the patient will be disinfected for three days following the procedure.	Buttocks	Deep subdermal and subcutaneous fat above muscle fascia	200 ml (100 ml per each side)	Lidocaine	N/A	18 months
Santorelli et al. [8]	> 24 months	Multilayer tunneling technique	Macromolecular HA (Naturalize Body Intense, Naturalize GmbH, Germany).	16G or 18G cannula	Markings of the site, cannula entry holes, disinfection, mixed local anesthesia and adrenaline applied, skin cut using blade 11, cannula insertion, administration of additional anesthetic and adrenaline through cannula, detaching of the treatment area, insertion of HA vial and injection after 10 minutes, post-injection massage to dilute filler, closure of the access holes by small prolene 5/0 sutures	Buttocks	Gluteal fat	160 ml	Mix (lidocaine and adrenaline)	N/A	6 months
Camenisch et al. [23]	> 12 Months	Multiple tunneling technique	HA	16G Cannula for LA, 12G Cannula for HA	Sterilization, local anesthesia, IV Flucloxacillin prophylactic, incision made for cannula, cannula inserted	Buttocks	Deep subcutaneous fatty tissue supramuscular	162.5 ± 22.5 ml of HA gel	0.5% lidocaine with epinephrine	1	1, 6, 12, and 24 months after treatment
De Meyere et al. [22]	24 Months	Multiple tunneling technique	HA	12G Cannula	Prophylactic antibiotics, local anesthesia, some patients received sedatives, and an incision was made for the cannula	Buttocks	Deep subcutaneous fatty tissue supramuscular	200–420 ml	0.5 or 1 % lidocaine with epinephrine	1 initial, 17 received touch-up treatment	24 months
Glancey [26]	4 months	N/A	HA (Type N/A)	N/A	Hip dip injections are administered three times each time with 75 ml per side	hip dips	N/A	225 ml per each side (over 3 times)	N/A	3	4 days
Che Ani et al. [20]	N/A	N/A	HA (Type N/A)	N/A	Self-injection	breasts and buttocks	N/A	100 ml (breasts and buttocks)	N/A	routine injections (unspecified)	N/A
Claude et al. [25]	9 months	N/A	HA	12G Cannula	Antibiotics, antiseptics, local anesthesia, cannula insertion	Buttocks	Deep subcutaneous fatty tissue supramuscular	220–320 ml	N/A	N/A	18 months

Table 2 continued

Authors	Duration of product effectiveness	Injection technique	Material used	Injection equipment used	Injection protocol	Location of injection	Injection plane	Quantity (Units)	Type of anesthesia	Frequency of injection	Follow-up duration
Lourenço et al. [19]	N/A	10 line fan form	HA	18G Cannula	Incision for cannula, prophylactic antibiotic, local anesthesia, and site marking	Buttocks	Subcutaneous	20 ml for the entire buttock, per session.	N/A	N/A	N/A
El-Khalawany et al. [18]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Uz et al. [21]	Until complications develop within a few hours	N/A	HA (type N/A)	N/A	N/A	Buttocks	N/A	N/A	N/A	7 previous HA injections	20 days

documented in the literature as probable and highly manageable complications with low potential with no potential of causing any significant impairments or fatal events, evidenced by past experiences [28]. We believe that the minor local complications encountered during HA injections to the buttocks can be attributed to the thick nature of the gel utilized which is highly likely to cause encapsulations and associated contour irregularities, swelling, gel displacements, and erythema. Moreover, the major complications due to HA injections that have been described in the literature include a case report by Ani et al. which documented a case of a 38-year-old woman who had been diagnosed with diffuse alveolar hemorrhage and acute myocardial infarction that progressed to death following the patient's self-injection with HA dermal filler [20]. Although this outcome is remarkably concerning, the authors did not rule out all the other possible causes of death that may have contributed to that outcome, especially since the patient had a history of self-injecting herself with various substances for cosmetic purposes. One explanation could be that the patient may have caused herself a fatal fat embolism in the same mechanism a fat embolism syndrome would typically occur during fat grafting for gluteal augmentation. Due to the patient's improper self-injecting technique, which was performed blindly and in a crude manner, accidental needle displacement and injury to the gluteus maximus muscle and gluteal fascia could have resulted in the fatal migration of fat and the injecting substance from the buttocks area, causing a fatal embolism. Therefore, similar to fat injections, strict adherence to the subcutaneous plane only during the administration of injectables in the gluteal region is of utmost importance and priority for ensuring high patient safety and preventing the occurrence of any major complications that may ultimately result in fatal outcomes like death. The emphasis on effective utilization of HA to reduce the associated costs implicated by the patients is of extreme importance, and vital significance to their safety, as well, since patients often get injected with poor quality HA injections to steer away from the elevated costs incurred with premium HA products.

Uz et al. also reported a case of a 46-year-old developing fat embolism syndrome (FES) after receiving an injection of HA at a beauty center which required immediate hospitalization and resuscitation. The patient eventually recovered and was discharged from the hospital since the recovery from FES is usually common, but could also be fatal [21]. This case documents an unusual presentation of FES following HA injections in the gluteal region with no strong evidence supporting HA as the actual cause in that case since that patient had previously received the same injections seven times prior to developing that major complication. The HA injections administered to

Table 3 Quantities of hyaluronic acid (HA) injected in total and per side

Study	Total injected (mL)	Quantity injected per side (mL)
Camenisch et al. [23]	Maximum of 400	162.5 ($\pm$ 22.5)
Claude et al. [25]	276 ml/subject (range: 220–320 ml)	138 ml (range: 110–160 ml)
Lourenço et al. [19]	20	10
Santorelli et al. [8]	Maximum of 400 (40 vials)	Mean 14.74 vials (SD, $\pm$ 3.52), (ranging: 8–20) 1 vial = 10 ml
Salahia and Dar [24]	200	100
Glancey et al. [26]	450	225
De Meyere et al. [22]	200–420 (mean: 340 $\pm$ 62 ml)	Not reported
Che Ani et al. [20]	100	Not reported
El-Khalawany et al. [18]	Not reported	Not reported
Uz et al. [21]	Not reported	Not reported

that patient were not provided by a certified physician or plastic surgeon and the procedure was performed in an unqualified/unequipped treatment setting that would allow for dealing with possible complications associated with injectables.

Currently, there is no single standardized aesthetic option for all gluteal augmentation procedures. Rather, gluteal contouring adheres to the same concept as the essence of plastic surgery and its individualistic approach and solutions to each specific problem, with a variety of options available in the surgeon's arsenal to tailor and personalize to each patient. The commonest options for correcting gluteal contour irregularities and restoring volume for gluteal defects include gluteal augmentation with implants, autologous fat grafting, local flaps, local tissue rearrangements, and HA gel or other filler injections. Oranges et al. concluded that all these options had high efficacy in gluteal augmentation and yielded high patient satisfaction rates. However, implant-based gluteal augmentations had the highest rates of complications among all procedures, autologous fat grafting had the highest risk of causing fat embolism syndrome, and local flaps as well as local tissue rearrangements were mostly indicated for massive weight loss patients [10]. HA injections remain one of the relatively safe options being minimally invasive with the least incidence of causing major complications and effectively enhancing the gluteus contour for more than 2 years following treatment [22–24]. However, careful emphasis should be made on the quantities injected, the appropriate technique of injection, and the possible risks associated since deciding on injecting HA to the buttocks is not completely risk-averse. On the contrary, HA injections may pose an even similar risk to fat grafting when applied crudely without paying respect to the anatomical borders, under no ultrasound visualization, using poor quality HA

products, and with inappropriately high quantities. All these factors contribute to a greater risk of minor and major complications like emboli which may ultimately cause death. Currently, there is no consensus in the literature on what specific quantity of HA represents the sweet spot of obtaining the highest safety along with the greatest efficacy and long-term product effectiveness. However, through our review of 8 studies that mentioned the quantities of HA injected in their subjects, we found an estimated mean of 250.75 ml of HA injected per subject in a single session. The minimum quantity injected was 20 ml per buttock per session in the study conducted by Lourenco et al. However, most of the studies had quantities injected between 200 and 400 ml of HA per subject in a single session. Additionally, HA injections possess the unique aptness in treating patients with lipoatrophy or low BMI who may not be indicated for fat grafting due to the unavailability of sufficient donor fat for harvesting [25]. It is critical to compare and contrast other gluteal augmentation. There are various methods available for individuals looking to enhance their buttocks. These techniques include implants, autologous fat injections, flaps, HA injections, Sculptra (poly-L-lactic acid) injections, and threads. Each method has its own advantages and disadvantages. Each of the gluteal augmentation methods is compared in Table 7 based on their advantages and disadvantages. The choice of method should depend on the patient's preference, goals, and medical history, with the guidance of a board-certified plastic surgeon.

To our knowledge, this literature focuses on role of gluteal augmentation with HA, which is yet to be evaluated in a systematic review. Another strength is the inclusion of a clear consensus among patients regarding their satisfaction with the aesthetic appearance of gluteal augmentation with HA. The majority of studies cited in the literature

Table 4 An overview of the included articles on gluteal HA augmentation and their strengths and weaknesses and clinical recommendations

Authors	Study strengths	Study weaknesses	Clinical recommendations (conclusion)
Salahia and Dar [24]	There were no major complications and the patient was highly satisfied	The sample size is small (2 patients)	It is recommended that HA be used for GA and contouring, as it is well tolerated, high in patient satisfaction, less invasive, safe, and without or with low SE. It is preferred to prosthesis implantation surgery for GA
Santorelli et al. [8]	A large sample size (43 patients), statistically significant increase in BODY-Q satisfaction scores, no major complications, only 7% of patients reported minor complications	Unspecified minor complications, short follow-up period (6 months)	Manage GA with HA as a prosthetic implant procedure within the first two years. Ensure maximum sterility during surgical procedures. Provide post-operative treatment with prednisone, broad spectrum antibiotics, analgesics, and supportive therapy
Camenisch et al. [23]	There were no major complications, and a magnetic resonance imaging examination was performed	The sample size is small	In the buttocks, non-animal stabilized hyaluronic acid gel degraded as expected and minimal displacement was observed. The treatment was well tolerated and effectively enhanced the appearance of the buttocks. In spite of the fact that only small amounts of gel remained, subjects and investigators perceived aesthetic improvement as high
De Meyere et al. [22]	Sample size is large, several countries are involved, there are no major complications, this is the first study to use a high volume of HA, well documented management of dislocation, and significant improvement has been observed	A lack of emphasis was placed on the dislocation of the HA	In terms of volume enhancement and contouring of the buttocks, stabilized HA gel is a safe and effective minimally invasive alternative to permanent implants and fat grafts. Despite the fact that the substance degrades over time, a large percentage of subjects rated their buttocks as improved and expressed satisfaction with the results 24 months after treatment
Glancey [26]	Documentation and management of infections following regular HA injections are of high quality	The sample size was small (one patient), the patient's improvement after complication was not elaborated on, and long-term post-complication follow-up was not provided	The development of an infection following an HA injection should be assessed and treated as soon as possible in order to avoid the development of an abscess in the future. Taking high doses of steroids and dissolving HA with hyalase along with antibiotics is effective in managing the infection and preventing abscess formation
Che Ani et al. [20]	Documentation of an unusual fatal outcome caused by ACS following injection of HA	HA was self-injected without an explanation of the quantity or method of administration. Additionally, the patient had self-injected with a number of substances, and any of these substances could have contributed to this fatal outcome. Hypoxemia and pulmonary thromboembolism were excluded as probable causes, but the study speculated that HA was the cause	Be aware that illicit injections of HA dermal fillers can result in DAH and myocardial infarction, even in previously healthy individuals

Table 4 continued

Authors	Study strengths	Study weaknesses	Clinical recommendations (conclusion)
Claude et al. [25]	There were no major complications, a follow-up magnetic resonance imaging was performed, and a significant improvement was noted	There are limited long-term data due to a small sample size and a loss of follow-up	According to this pilot study, Macrolane treatment for buttock lipoatrophy is a promising and well-tolerated method for reducing pain while sitting and improving buttock appearance
Lourenço et al. [19]	An innovative technique	No sample size was provided, no demographic information about the patients, no follow-up was provided, complications were not mentioned	It has been demonstrated that LL body contouring for gluteal augmentation is a minimally invasive procedure, with quick results, without major risks and downtime. Patients experienced increased self-esteem and quality of life as a result of this treatment
El-Khalawany et al. [18]	A sufficient sample size	An inability to determine the true percentage of complications associated with each type of filler based on the total number of patients who have been injected	Currently, dermal fillers are one of the most popular cosmetic procedures. There may be a variety of clinical manifestations and histological reactions associated with dermal fillers. The purpose of this article is to increase awareness regarding the recognition of these variable complications and to assist in selecting the most appropriate treatment for each
Uz et al. [21]	Good follow-up period, detailed documentation of FES as an unusual complication following buttock injections, and approach to management of this complication until it is resolved	The sample size is small (1 patient), there is no clear explanation for how FES could have arisen from HA buttock injection, especially since the patient had previously been injected with HA seven times	If a patient presents to the emergency department with altered mental status following aesthetic procedures, the diagnosis of FES complication is clinical and imaging may expedite the diagnosis and treatment. The outcomes of FES as a complication are generally good

Table 5 A qualitative assessment of the case report and case series included

Domain for evaluating the methodological quality of case reports and case series									Quality score	Risk of bias
References	Leading explanatory questions									
	Selection	Ascertainment		Causality		Reporting				
	Q. 1	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6	Q. 7	Q. 8		
Che Ani et al. [20]	Yes	Yes	Yes	Yes	No	No	No	Yes	Fair-Quality Study (7)	Moderate Risk
Uz et al. [21]	Yes	Yes	Yes	Yes	No	No	No	Yes	Good Quality Study (9)	Low Risk
Glancey [26]	Yes	Yes	Yes	Yes	No	No	No	Yes	Good quality study (9)	Low risk

Selection: [question 1]. Does the patient(s) represent(s) the whole experience of the investigator (center) or is the selection method unclear to the extent that other patients with similar presentations may not have been reported?

Ascertainment: [question 2]. Was the exposure adequately ascertained? [question 3]. Was the outcome adequately ascertained?

Causality: [question 4]. Were other alternative causes that may explain the observation ruled out? [question 5]. Was there a challenge/rechallenge phenomenon? [question 6]. Was there a dose–response effect? [question 7]. Was follow-up long enough for outcomes to occur?

Reporting: [question 8] Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners to make inferences related to their own practice?

Table 6 The Newcastle–Ottawa Scale for the included cohort prospective and retrospective studies

References	Selection			Comparability		Outcome			Quality score	Risk of bias (0–3: High, 4–6: Moderate, 7–9: low)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8		
Camenisch et al. [23]	*	*	*	*	**	*	*	*	Good quality Study (9)	Low risk
Claude et al. [25]	(c) Selected group of users	*	(c) Written self-report	*	**	*	*	High risk of bias, 60% lost to follow-up	Fair-quality study (6)	Moderate risk
De Meyere et al. [22]	*	*	*	*	**	*	*	*	Good quality study (9)	Low risk
El-Khalawany et al. [18]	*	(c) No description of the derivation of the non-exposed cohort	*	*	*	*	*	*	Good Quality Study (7)	Low risk
Lourenço et al. [19]	(d) No description of the derivation of the cohort	*	*	*	No comparability	*	no	d) no statement	Poor Quality Study (4)	Moderate risk
Santorelli et al. [8]	(c) Selected group of users	*	*	*	**	*	no	*	Good Quality study (7)	Low risk
Salahia and Dar [24]	(c) Selected group of users	(c) No description of the derivation of the non-exposed cohort	*	*	no comparison group	(c) Self report	*	*	Poor Quality Study (4)	Moderate risk

Selection: Q1 Representativeness of the exposure cohort? Q2. Selection of the non-exposure cohort? Q3. Ascertainment of exposure? Q4. Demonstration that outcome of interest was not present at start of the study?

Comparability: Q5 Comparability of cohort on the basis of the design or analysis?

Outcome: Q6 Assessment of outcome? Q7. Was follow-up long enough for outcomes to occur? Q8. Adequacy of follow-up of cohorts?

acknowledge patient satisfaction with the outcomes and safety of HA for gluteal augmentation. Our study's robustness is based on the strict inclusion and exclusion criteria, which was conducted in accordance with the PRISMA criteria with no deviations from the protocol. The study has some limitations that should be taken into consideration when interpreting the results. Firstly, the sample size is relatively small, with only 10 papers being included in the review. Among these papers, there were reports of

single cases or very small sample sizes, which made it difficult to perform statistical analyses or draw definitive conclusions. In addition, the studies included in the review had varying levels of evidence, with only one study being at level II, and the majority being at level IV or V. Furthermore, the studies included patients assisted by doctors and non-doctors, which may introduce a certain level of bias and heterogeneity to the results. Another limitation is the inability to include quantitative meta-analyses due to

Table 7 Comparison of pros and cons for gluteal augmentation techniques

Technique	Pros	Cons
Implants [28, 29]	(a) Long-lasting results (b) Predictable and consistent outcome (c) Less chance of reabsorption compared to fat injections (d) Suitable for individuals with little body fat (e) Resistant to weight fluctuations	(a) Invasive surgical procedure (b) Longer recovery time (c) Potential complications like infection, implant displacement, or capsular contracture (d) Higher cost (e) May not look or feel as natural as fat grafting
Fat Injections (Brazilian Butt Lift) [30]	(a) Natural-looking results (b) Utilizes patient's own fat, reducing risk of allergic reactions (c) Dual benefit of liposuction from donor sites (d) Less invasive compared to implants (e) Lower risk of complications	(a) Limited by availability of donor fat (b) Possibility of fat reabsorption (c) Multiple sessions might be needed for desired results (d) Results can be affected by weight fluctuations (e) Rare but serious complications like fat embolism
Flaps [31]	(a) Autologous tissue (patient's own) used (b) Natural-looking and long-lasting results (c) Can address both volume and shape concerns (d) Suitable for reconstructive purposes	(a) Highly invasive procedure (b) Long recovery time (c) Potential complications like tissue necrosis, infection, or scarring (d) Limited by availability of suitable tissue (e) High cost (f) size shifts with weight
HA Injections [9]	(a) Non-surgical, minimally invasive procedure (b) Immediate results (c) Low risk of allergic reactions, as HA is a naturally occurring substance (d) Adjustable volume (e) Temporary, allowing for adjustments or reversibility	(a) Short-term results, typically lasting 6–12 months (b) Multiple treatments needed for maintenance (c) Limited volume enhancement compared to other methods (d) Can be expensive over time (e) Rare complications like infection or granuloma formation
Sculptra Injections [32]	(a) Non-surgical, minimally invasive procedure (b) Stimulates collagen production for gradual, natural-looking results (c) Long-lasting effects, up to 2 years (d) Biocompatible and biodegradable (e) Lower risk of complications compared to more invasive procedures	(a) Multiple sessions required for optimal results (b) Delayed results, as collagen production takes time (c) Limited volume enhancement compared to other methods (d) Can be expensive over time (e) Rare complications like infection or nodules formation
Threads [33]	(a) Non-surgical, minimally invasive procedure (b) Immediate lifting effect (c) Shorter recovery time compared to invasive procedures (d) Can be combined with other non-surgical treatments (e) Low risk of complications	(a) Short-term results, typically lasting 1–2 years (b) Limited volume enhancement compared to other methods (c) Multiple treatments needed for maintenance (d) Can be expensive over time (e) Rare complications like infection, thread migration, or extrusion

the disparities in methodologies, interventions, insufficient extracted data, and outcomes measured. The authors of this study have evaluated the quality of the literature that were included and assessed the risk of bias. The risk of bias was assessed by two independent reviewers. Regardless of whether the material appeared to be biased, both reviewers reached the same conclusion. A high-quality randomized controlled trials should be conducted, to measure other

patient-related variables that influence overall patient satisfaction and efficacy of HA gluteal augmentation. To accurately assess the complication rate of HA injection, we recommend conducting a high-quality prospective study that evaluates/assesses how different clinical variables such as patients' chronic illnesses, and non-clinical variables such as physical activity, may interplay with HA injections

and affect their effectiveness and complication rates in gluteal augmentation.

Conclusion

In conclusion, although the findings suggest that HA injections could be an appropriate and effective option for enhancing the appearance of the gluteus, larger studies are necessary to make more definitive conclusions and to determine whether HA injections should be recommended over more established injection methods. Moreover, our review confirms high patient satisfaction, long-term aesthetic outcomes, and product effectiveness for more than 24 months following treatment. Complications encountered were mostly minor in nature apart from two significant events that were not directly linked to HA injections administration. Additionally, gluteal HA injections have a uniquely therapeutic and aesthetic ability to treat patients with low BMI who may not be candidates for fat grafting which positions it as another viable and highly advantageous option that could be incorporated into the plastic surgeon's reconstructive and aesthetic toolbox to address a variety of gluteal aesthetic and functional challenges.

Acknowledgment This work was supported by the College of Medicine Research Center, Deanship of Scientific Research, King Saud University Medical City, and King Saud University, Riyadh, Saudi Arabia.

Funding The authors do not have any conflict of funding to declare.

Declarations

Conflict of interest The authors do not have any conflict of interest.

Human and Animal Rights, or Ethical Approval Not applicable due to the nature of the study.

Informed Consent Not applicable due to the nature of the study.

References

- Kim JE, Sykes JM (2011) Hyaluronic acid fillers: history and overview. *Facial Plastic Surg FPS* 27(6):523–528. <https://doi.org/10.1055/s-0031-1298785>
- Tezel A, Fredrickson GH (2008) The science of hyaluronic acid dermal fillers. *J Cosmet Laser Ther* 10(1):35–42. <https://doi.org/10.1080/14764170701774901>
- Gold MH (2007) Use of hyaluronic acid fillers for the treatment of the aging face. *Clin Interv Aging* 2(3):369–376. <https://doi.org/10.2147/cia.s1244>
- Wongprasert P, Dreiss CA, Murray G (2022) Evaluating hyaluronic acid dermal fillers: a critique of current characterization methods. *Dermatol Ther* 35(6):e15453. <https://doi.org/10.1111/dth.15453>
- Abduljabbar MH, Basendwh MA (2016) Complications of hyaluronic acid fillers and their managements. *J Dermatol Dermatol Surg* 20(2):100–106
- Kalmanson OA, Misch ES, Terella A (2022) Hyaluronic acid fillers may be longer-lasting than previously described: a case report of delayed filler-associated facial cellulitis. *JPRAS Open* 33:37–41. <https://doi.org/10.1016/j.jpra.2022.05.011>
- Mortada H, Seraj H, Barasain O, Bamakhrama B, Alhindi NI, Arab K (2022) Ocular complications post-cosmetic periocular hyaluronic acid injections: a systematic review. *Aesthet Plast Surg* 46(2):760–773. <https://doi.org/10.1007/s00266-021-02730-5>
- Santorelli A, Cerullo F, Salti G, Avvedimento S (2022) Gluteal augmentation with hyaluronic acid filler: a retrospective analysis using the BODY-Q scale. *Aesthet Plast Surg*. <https://doi.org/10.1007/s00266-022-03166-1>. Advanceonlinepublication.10.1007/s00266-022-03166-1
- Atiyeh B, Ghieh F, Oneisi A (2023) Safety and efficiency of minimally invasive buttock augmentation: a review. *Aesthet Plast Surg* 47(1):245–259. <https://doi.org/10.1007/s00266-022-03049-5>
- Oranges CM, Tremp M, di Summa PG, Haug M, Kalbermatten DF, Harder Y, Schaefer DJ (2017) Gluteal augmentation techniques: a comprehensive literature review. *Aesthet Surg J* 37(5):560–569. <https://doi.org/10.1093/asj/sjw240>
- Dai Y, Chen Y, Hu Y, Zhang L (2022) Current knowledge and future perspectives of buttock augmentation: a bibliometric analysis from 1999 to 2021. *Aesthet Plast Surg*. <https://doi.org/10.1007/s00266-022-03140-x>. Advanceonlinepublication.10.1007/s00266-022-03140-x
- Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 6(7):1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Higgins J, Green S (eds.) (2011) *Cochrane Handbook for Systematic Reviews of Interventions*, Version 5.1.0. Available at <https://training.cochrane.org/handbook>. Accessed 1 June 2021
- Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A (2016) Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 5(1):1–10
- Murad MH, Sultan S, Haffar S, Bazerbach F (2018) Methodological quality and synthesis of case series and case reports. *BMJ Evid Based Med* 23(2):60–63. <https://doi.org/10.1136/bmjebm-2017-110853>
- Stang A (2010) Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol* 25(9):603–605. <https://doi.org/10.1007/s10654-010-9491-z>
- Sullivan D, Chung KC, Eaves FF 3rd, Rohrich RJ (2021) The level of evidence pyramid: indicating levels of evidence in plastic and reconstructive surgery articles. *Plast Reconstr Surg* 148(5S):68S–71S. <https://doi.org/10.1097/01.prs.0000794868.07051.b4>
- El-Khalawany M, Fawzy S, Saied A, Al Said M, Amer A, Eassa B (2015) Dermal filler complications: a clinicopathologic study with a spectrum of histologic reaction patterns. *Ann Diagn Pathol* 19(1):10–15. <https://doi.org/10.1016/j.anndiagpath.2014.11.004>
- Lourenço LM, de Noronha MGO, Colla LA, Izzo TR, Sigrist R, Braz A (2022) LL body contour technique—a new way of gluteal contouring and augmentation with hyaluronic acid filler. *J Cosmet Dermatol* 21(5):1967–1972. <https://doi.org/10.1111/jocd.14763>
- Che Ani AA, Mohd Akhir S, Chiang Li-Xue W, Shahidan NZ, Abd Hamid A (2021) Diffuse alveolar haemorrhage and myocardial infarction: life-threatening effects from self-injected

- hyaluronic acid dermal filler. *Monaldi Arch Chest Dis*. <https://doi.org/10.4081/monaldi.2021.1845>
21. Uz İ, Yalçın S, Efe M (2020) Fat embolism syndrome after gluteal augmentation with hyaluronic acid: a case report. *TJTES* 26(6):960–962. <https://doi.org/10.14744/tjtes.2019.08433>
 22. De Meyere B, Mir-Mir S, Peñas J, Camenisch CC, Hedén P (2014) Stabilized hyaluronic acid gel for volume restoration and contouring of the buttocks: 24-month efficacy and safety. *Aesthet Plast Surg* 38(2):404–412. <https://doi.org/10.1007/s00266-013-0251-9>
 23. Camenisch CC, Tengvar M, Hedén P (2013) Macrolane for volume restoration and contouring of the buttocks: magnetic resonance imaging study on localization and degradation. *Plast Reconstr Surg* 132(4):522e–529e. <https://doi.org/10.1097/PRS.0b013e31829fe47e>
 24. Salahia S, Dar TM (2022) Hyaluronic acid: a safe, biodegradable and biocompatible product for buttock augmentation and contouring. *Eur J Med Health Sci* 4(3):57–61
 25. Claude O, Bosc R, Pigneur F, Lantieri L (2015) Treatment of HIV-infected subjects with buttock lipoatrophy using stabilized hyaluronic acid gel. *Plastic and reconstructive surgery*. *Global open* 3(7):e466. <https://doi.org/10.1097/GOX.0000000000000423>
 26. Glancey L (2022) The impact of the BBL ban in the UK on patients seeking buttock augmentation. *Case Rep Rev Open Access* 3(1):127
 27. Hedén P, Sellman G, von Wachenfeldt M, Olenius M, Fagrell D (2020) Body shaping and volume restoration: the role of hyaluronic acid. *Aesthet Plast Surg* 44:1286–1294
 28. Sinno S, Chang J, Brownstone N, Saadeh P, Wall S (2016) Determining the safety and efficacy of gluteal augmentation: a systematic review of outcomes and complications. *Plast Reconstr Surg* 137(4):1151–1156. <https://doi.org/10.1097/PRS.0000000000002005>
 29. Flores-Lima G, Eppley BL, Dimas JR, Navarro DE (2013) Surgical pocket location for gluteal implants: a systematic review. *Aesth Plast Surg* 37(2):240–245. <https://doi.org/10.1007/s00266-012-0018-8>
 30. Condé-Green A, Kotamarti V, Nini K (2016) Fat grafting for gluteal augmentation: a systematic review of the literature and meta-analysis. *Plast Reconstr Surg* 138(3):437e–446e. <https://doi.org/10.1097/PRS.0000000000002435>
 31. Colwell AS, Borud LJ (2007) Autologous gluteal augmentation after massive weight loss: aesthetic analysis and role of the superior gluteal artery perforator flap. *Plast Reconstr Surg* 119(1):345–356. <https://doi.org/10.1097/01.prs.0000244906.48448.5d>
 32. Lin M, Dubin D, Khorasani H (2020) Poly-L-lactic acid for minimally invasive gluteal augmentation. *Dermatol Surg* 46(3):386–394. <https://doi.org/10.1097/DSS.0000000000001967>
 33. Lee W, Jung Y, Yang E (2021) Gluteal soft-tissue repositioning using polydioxane threads. *Dermatol Surg* 47(7):e195–e199. <https://doi.org/10.1097/DSS.0000000000002975>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.