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Published in:
Journal of Plastic Reconstructive and Aesthetic Surgery

DOI:
[10.1016/j.bjps.2021.11.051](https://doi.org/10.1016/j.bjps.2021.11.051)

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2022

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Hijkoop, L. F., Stevens, H. P. J. D., & van der Lei, B. (2022). The minimal access cranial suspension (MACS) lift: A systematic review of literature 18 years after its introduction. *Journal of Plastic Reconstructive and Aesthetic Surgery*. <https://doi.org/10.1016/j.bjps.2021.11.051>

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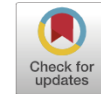
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Review

The minimal access cranial suspension (MACS) lift: A systematic review of literature 18 years after its introduction

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Received 10 January 2021; accepted 8 November 2021

KEYWORDS

MACS lift;
Facial surgery;
Facelift;
Facial rejuvenation;
Esthetic surgery

Summary Background: One of the most popular short-scar rhytidectomy techniques used nowadays is the minimal access cranial suspension (MACS) lift developed by Tonnard and Vaerpele. The technique uses purse-string sutures in combination with limited skin undermining to obtain a clear vertical tissue repositioning.

Since its introduction, the technique has extensively been described and used around the world by facial plastic surgeons. Now, 18 years after its introduction, a systematic review concerning the results and complications of the MACS lift is presented to establish its current position in facial rejuvenation.

Methods: The MEDLINE, Embase, Cochrane Central, and Google Scholar databases were searched for studies evaluating the MACS lift (June 10, 2020). Outcomes of interest were long-term effect, satisfaction, and complications of the MACS lifting as determined by the patient and/or surgeon.

Results: Six studies were included, with 739 patients treated with the MACS lift in total. No major complications were reported, four studies did report on the occurrence of minor complications. All of the six studies reported relatively high levels of satisfaction. Three studies reported a shorter procedural duration for the MACS lift compared with the conventional facelift. In three of the six included studies, the level of evidence was low. The effect on neck rejuvenation is limited.

Conclusion: The MACS lift can be considered a minimally invasive facelift procedure with a relatively low complication rate. The procedure, often combined with additional procedures,

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results in evident patient and/or surgeon satisfaction. To obtain a better desired result on an aged neck area, additional procedures are warranted.

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Introduction

Since the first description by Passot in 1919,¹ the concept of short-scar rhytidectomies further developed over time, especially to satisfy the demands of relatively younger patients who are seeking facial rejuvenation. The main advantages of short-scar rhytidectomies are limited incisions, the absence of post-auricular scars, limited area of dissection, and less risk for nerve damage and postoperative hematomas.

One of the most popular short-scar rhytidectomy techniques used nowadays is the one developed by Tonnard and Vaerpele.² The technique has extensively been described using purse-string sutures in combination with limited skin undermining to obtain a clear vertical repositioning (resulting in true lifting with a strict vertical vector) instead of a sideways pull leaving a sling (Fig. 1). This is done by tightening of the superficial musculo-aponeurotic system (SMAS) resulting in a more cranial repositioning of the skin without pulling of the skin.

Since the introduction of the minimal access cranial suspension (MACS) lift in literature in 2002,² the technique has extensively been spread and used around the world by facial plastic surgeons. Now, 18 years after its introduction, a

systematic review concerning the results and complications of the MACS lift is presented to establish its current position in facial rejuvenation.

Methods

Protocol, information sources, and search

The MEDLINE, Embase, Cochrane Central, and Google Scholar databases were searched (June 10, 2020). The search was restricted from publication dates between 2002 and 2020. Keywords used for the search regarding the long-term effect and patient satisfaction of the MACS lift are shown (see Table S1, which shows the specific search terms used for the databases).

Eligibility criteria

Studies were included when the MACS lift was performed as described by Tonnard and Vaerpele in 2002; minor modifications regarding this technique were also accepted. Studies that compared the MACS lift with another type of facelift

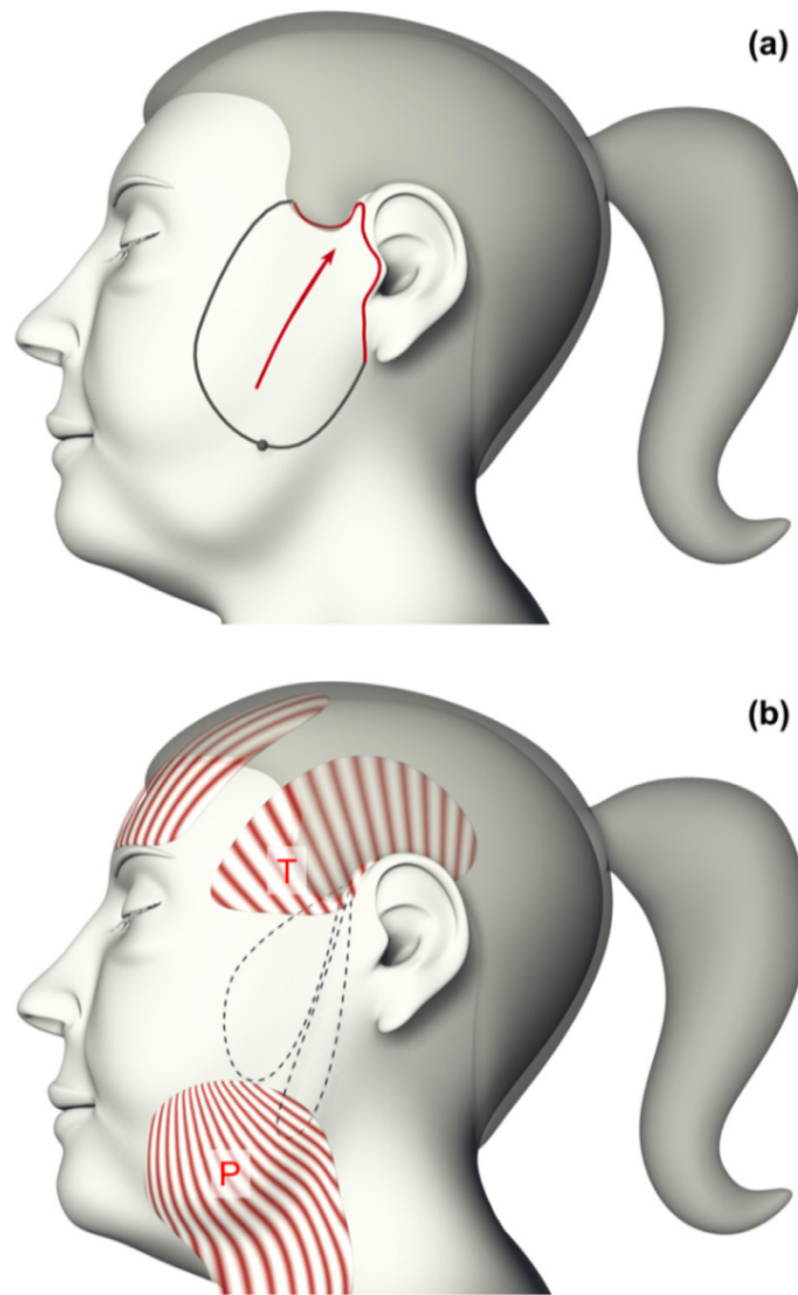


Fig. 1 Minimal Access Cranial Suspension (MACS) lift. (a) The incision (red) and skin undermining (black) in the MACS lift. The vector of correction is almost vertical (red arrow). (b) Projection of the two purse-string sutures (dashed lines) and their relationship to the temporalis (T) and platysma (P) muscles.⁶

were also included. To assess the long-term effect and patient satisfaction of the MACS lift, only studies were included with a minimal follow-up of 6 months that also report on complications or postoperative outcomes as well as patient and/or surgeon satisfaction. Studies performed on cadavers were excluded. Studies without mentioning clear patient-reported outcome measures or with less than 25 participants were excluded. Case reports, conference abstracts, books, and reviews were also excluded. Inclusion and exclusion criteria are listed in [Table 1](#).

Study selection

After the literature search was conducted, all the titles and abstracts of the found studies were screened for their eligibility and a selection of possible useful studies was made. Subsequently, two authors (L.F.H. and B.v.d.L.) independently selected clinical studies that met the eligibility criteria ([Fig. 2](#)). Inconsistencies were discussed during a consensus meeting.

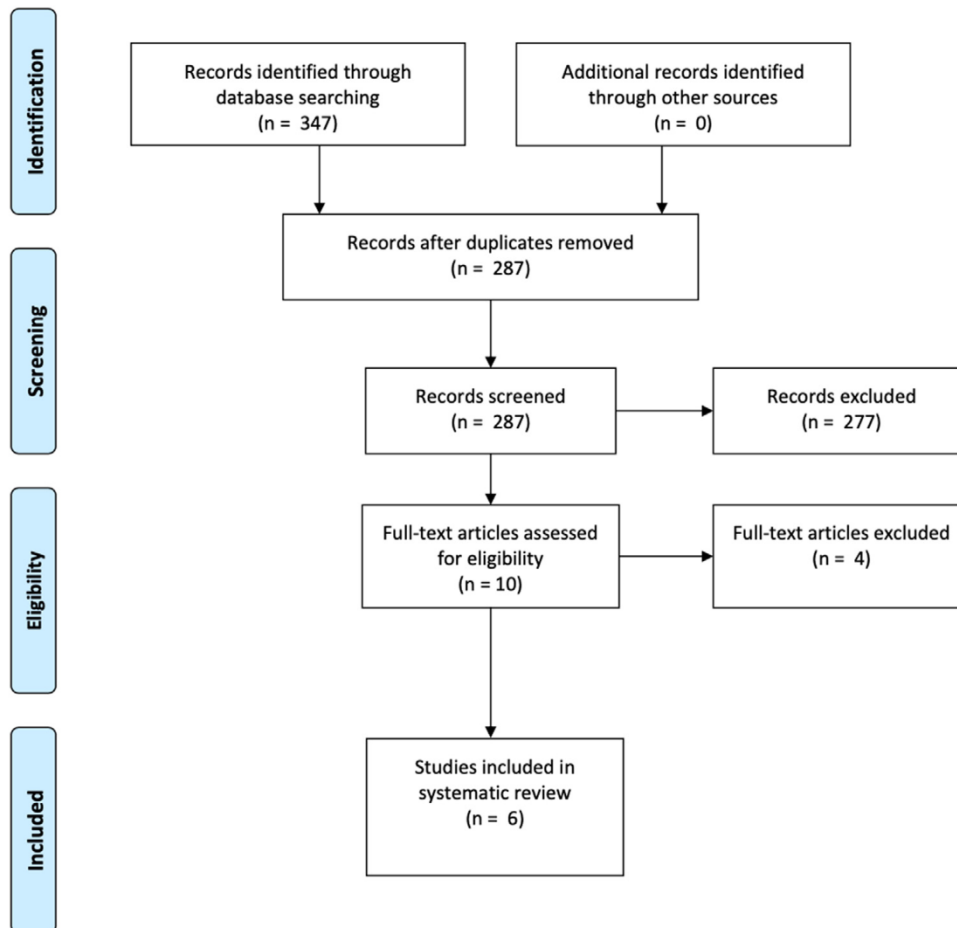


Fig. 2 Flow diagram of study selection.

Table 1 Inclusion and Exclusion criteria.

Inclusion criteria:

Minimal Access Cranial Suspension lift (with minor modifications)
 Follow-up longer than 6 months
 Complications or postoperative outcomes assessed
 Satisfaction or long-term effect investigated

Exclusion criteria:

Performed on cadavers
 Published before 2002
 No clear outcome measures described
 Less than 25 participants
 Case reports, conference abstracts, books, and reviews

Assessment of quality of included studies

The quality of the included studies was assessed using the Oxford Center for Evidence-Based Medicine Criteria.³

Outcomes

Outcomes of interest were long-term effect, satisfaction, and complications of the MACS lifting as determined by the patient and/or surgeon.

Results

Studies included

Literature search yielded 287 publications (Fig. 2). After title and abstract screening, 277 articles were excluded. Ten studies were read in full text and assessed on their eligibility. One study used a technique that differed significantly from the MACS lift and was therefore excluded.⁴ Four studies published by Tonnard and Verpaele described the same series of participants^{2,5-7} and, therefore, only their most recent publication was used for analysis.⁷

Quality assessment of included studies

Of the six included studies, three were level of evidence III studies,⁸⁻¹⁰ and three were level of evidence IV studies (Table 2).^{7,11,12}

Study characteristics

All of the six included studies are retrospective studies. In total, 693 subjects were treated with the MACS lift as described originally (plus or minus minor modifications). Fre-

Table 2 Study Characteristics and Patient Demographics.

Reference	Study Type	Level of Evidence ^Y	Sex		Age	
			Male	Female	Mean ± SD	Range
Tonnard et al., 2005 ⁷	Retrospective, non-randomized, non-blinded, non-controlled study	IV	35	415	57	39-86
Prado et al., 2006 ⁸	Retrospective, non-randomized, blinded, controlled study	III	2	80	47	42-55
Mast, 2014 ⁹	Retrospective, non-randomized, non-blinded, controlled study	III	3	85	59	-
Willemsen et al., 2011 ¹⁰	Retrospective, non-randomized, single-blinded, controlled study	III	-	-	50.8	40-63
Buchanan et al., 2018 ^{*11}	Retrospective, non-randomized, non-blinded, controlled, cohort study	IV	2	28	60.2	49-76
Yu et al., 2020 ¹²	Retrospective, non-randomized, non-blinded, non-controlled study	IV	0	46	50.7 ± 6.4	40-65

*Sex, mean ± age SD, and range are only given for the MACS cohort. No demographic data of the controlled group could be extracted.

^Y Quality assessment of included studies according to the Oxford Center of Evidence-Based Medicine Criteria³.

quently performed in combination with additional surgery, lipofilling and/or submental liposuction. In the study of Yu et al., 46 subjects were treated with a modified MACS lift using elastic threads.¹² The study characteristics and patient demographics of the included studies are listed in Table 2.

Intervention

Tonnard et al. investigated their traditional MACS lifting and often combined this procedure with additional therapies, such as facial lipofilling and submental liposuction.⁷ Prado et al. compared the MACS lift with the minimal incision rhytidectomy with lateral SMASectomy.⁸ Willemsen et al. compared the MACS lift alone with MACS lifting with adjuvant lipofilling (in case of loss of volume), with only minor modifications of the MACS lift.¹⁰ Mast et al. and Buchanan et al. compared the MACS lift with the conventional facelift; they both used some minor modifications of the MACS lift.^{9,11} Yu et al. investigated patients who underwent a modified MACS lift using an elastic thread.¹²

The modifications that were made to the MACS lift in these studies are listed in Table 3.

Clinical outcome

Procedural duration

Three of the six studies did not report on procedural duration.^{7,10,12} Prado et al. reported a mean procedural duration of 165 min for the MACS lift compared with 190 min for the lateral SMASectomy ($P = 0.0011$).⁸ Mast et al. reported a significantly longer operating time for the conventional facelift (4:03) than for the MACS lift (2:39) ($P = 0.002$ via Student's *t*-test).⁹ Buchanan et al. reported a significant reduction in the mean operating time for the MACS lift: 165.3 min compared with 222.1 min for traditional facelifts ($P = 0.000$).¹¹

Satisfaction

All of the six studies reported satisfaction of the MACS lift as determined by the patient and/or surgeon. Tonnard et al. reported that general patient satisfaction was very high. A retrospective analysis of 99 patients with a minimal follow-up of 1 year showed some higher expectations, but none of these were absolutely dissatisfied.⁵ Prado et al. assessed cosmetic outcomes utilizing the Strasser score, most patients scored "good" (79.3% for the SMASectomy and 85.4% for the MACS cohort), a "poor" result was not reported once.⁸ Buchanan et al. reported that surgeons, after objective analysis of postoperative outcomes, were immediately satisfied in 56% and 57% for the traditional facelift and MACS lift, respectively.¹¹ Mast et al. reported a high level of satisfaction for all conventional lifts, whereas 77 of 80 MACS lift patients were fully satisfied. Three patients of the MACS cohort expressed disappointment due to residual skin laxity or inadequate neck contouring.⁹ Yu et al. reported that in their series of 46 patients, 45 were satisfied immediately after the procedure. At 6-month and 1-year follow-ups, respectively, 41 and 39 patients were still satisfied with the results of the MACS lift.¹²

Willemsen et al. evaluated the results of the MACS lifting with or without simultaneous lipofilling of the face, using a photographic ranking analysis of different zones of the face (using two panels consisting of five plastic surgeons and five medical students). Concurrent lipofilling improved the nasojugal groove and malar eminence to a statistically significant degree when compared with MACS lifting alone.¹⁰

Additional procedures

Two of the six studies did not mention additional procedures performed with MACS lifting.^{9,10,12} Tonnard et al. stated that in 23 (5.1%) of their series of 450 MACS lifts an additional neck procedure was needed.⁷ Prado et al. reported that evaluation at 2-year follow-up revealed that more than 50% of their series needed a tuck procedure to correct redundant skin and jowling as judged by the surgeons.⁸ Buchanan et al. reported 19 (63.3%) patients with concurrent facial procedures of their series of 30 MACS lifts

Table 3 Intervention Type and Modifications made.

Reference	Intervention type	Modifications made to Minimal Access Cranial Suspension (MACS) lift
Tonnard et al., 2005 ⁷	Traditional MACS lift	The traditional MACS lift was often combined with additional therapies such as lipofilling.
Prado et al., 2006 ⁸	MACS lift vs lateral SMASectomy	No modifications were made.
Mast, 2014 ⁹	MACS lift vs traditional facelift	After some experience, the technique was slightly modified: incision line into the temple and sideburn was made to curve more and zigzag less. The oblique purse-string suture for the midface was made wider and longer (accomplishing better midface soft tissue and malar fat pad elevation).
Willemsen et al., 2011 ¹⁰	MACS lift vs MACS lift with adjuvant lipofilling	The most caudal point of the first suture loop was placed lower than initially described by Tonnard and Verpaele. This yielded a more pronounced effect on the jawline. The second purse-string suture was more O-shaped (same starting point but directed to the extent of the subcutaneous dissection). Photo ranking analysis was performed showing for the first time that adding lipofilling resulted in a significant higher appreciated esthetic outcome than lifting alone.
Buchanan et al., 2018 ¹¹	MACS lift	The oblique purse-string suture used for midface soft tissue and malar fat pad elevation was made wider and longer. A third purse-string suture was not used and cervical regions were not opened.
Yu et al., 2020 ¹²	Elastic thread MACS lift	Elastic threads were used for the purse-string sutures.

compared with 11 (68.8%) in their series of 16 traditional facelifts. They reported an increase in concurrent non-facial procedures ($P = 0.035$) for the MACS lift.¹¹ Willemsen et al. demonstrated that lipofilling can significantly improve the outcome of MACS lifting, particularly in the nasojugal groove and malar eminence regions.¹⁰

Complications

Two of the six studies did not specifically mention complications as a result of the MACS lift.^{10,11} Tonnard et al. reported that in their series of 300 patients, there were no major complications, such as permanent facial branch paralysis, skin slough, or ectropion. The incidence of minor complications was also low: six hematomas that required drainage; three cases of infection in the horizontal limb of the scar; in ten cases, the knots of the Prolene suture were palpable, and in six cases, the knots were irritating. The cases of infection seemed to be caused by a suppurating subcutaneous Vicryl suture. Palpable or irritating suture knots were removed under local anesthesia at 6 months postoperative and no deterioration of the result was seen after removal.⁵

Prado et al., who compared the MACS lift with the lateral SMASectomy of Daniel Baker,¹³ reported on the occurrence of two hematomas in their series of 82 patients (41 cases of lateral SMASectomy and 41 cases of MACS lift) one for each technique. Moreover, they reported two cases of retroauricular-lobule dog-ears that needed minor surgical revision and one case of hypertrophic preauricular scars for the MACS lift.⁸ Mast et al. reported four complications in their series of 88 patients (eight conventional lifts and 80 MACS lifts), all in the large MACS cohort: three hematomas that required drainage and a case of temporary buccal branch paresis, which fully resolved within 3 months. The

authors noted that in general, hematomas are more easily dealt with in MACS lifting compared with conventional facelifting due to the limited skin undermining.⁹ Yu et al. reported in their series of 46 patients no major complications, however, five patients presented with mild swelling of the surgical site and three with seroma.¹² The results of the MACS lift are summarized in [Table 4](#).

Discussion

This systematic review clearly reconfirms the still actual value of the MACS lift or the short-scar facelifting for that matter. It also shows that the procedure, often used in combination with additional procedures, results in evident patient satisfaction with a relatively low complication rate, as was initially advocated by Tonnard and Verpaele.² However, inadequate neck contouring and skin laxity were reported in several studies,^{7,9,11} and additional procedures, for example, tuck procedures, were frequently needed to obtain a satisfactory result.^{7,8} Therefore, it can be assumed that there is no extensive effect of the MACS lift on the neck area. Even with more extensive facelift procedures, such as described in the prize-winning paper of Pelle-Ceravolo, Angelini and Silvi,¹⁴ recurrence of neck laxity and platysma bands is a matter of concern, unless more specific procedures are performed for the neck.^{15,16} Patients with excess skin laxity and/or bulky necks are not ideal candidates for MACS lifting, making patient selection very important.¹¹ This needs to be taken into consideration while interpreting results of the included studies. Since not all studies did describe how patients were selected for the MACS cohort and if neck bulk and skin elasticity were taken into account. Cor-

Table 4 Results of the Minimal Access Cranial Suspension (MACS) lift.

Reference	Study population	Method of Measurement	Follow-up Period	Results	Complications
Tonnard et al., 2005 ⁷	<i>n</i> = 450 MACS lifts	Adequate results and requirement of additional procedures.	Not mentioned	In 94.9% of the cases, MACS lifting with submental liposuction gave adequate results. In 23 cases an additional neck procedure was necessary.	No major complications in their series of 300 patients. Six hematomas; three cases of infection of the scar; ten cases of palpable knots of the suture and six cases of irritating suture knots.
Prado et al., 2006 ⁸	<i>n</i> = 41 SMASectomies <i>n</i> = 41 MACS lifts	Frontal, oblique, and lateral photographs were evaluated by patients and two blind surgeons with Strasser scores. Postoperative pain and surgical time.	1 and 24 months postoperatively	Most patients scored the overall final cosmetic result as “good” (79.3% for the SMASectomy and 85.4% for the MACS lift), a “poor” result was not reported once. Satisfaction showed no significant difference with either technique. Photographic evaluation at 24 months revealed that more than 50 percent of the sample (<i>n</i> = 82) needed a tuck procedure. Postoperative pain was worse for the MACS lift but surgical time was shorter.	Two hematomas, one for each technique. For the MACS lift two cases with retroauricular-lobule dog-ears that needed surgical revision and one case with hypertrophic preauricular scars.
Mast, 2014 ⁹	<i>n</i> = 8 conventional facelifts <i>n</i> = 80 MACS lifts	Operating time, return to work, and patient satisfaction.	4-40 months (6 months average)	Operating times were longer for the conventional facelift. The average return to work was 2 weeks in the MACS group. All conventional lift patients had a high level of satisfaction, whereas 96% of the MACS group was fully satisfied. Three MACS patients expressed disappointment.	All in the MACS group: three hematomas that required drainage and one temporary buccal branch paresis which fully resolved within 3 months.
Willemsen et al., 2011 ¹⁰	<i>n</i> = 50 MACS lift alone <i>n</i> = 42 MACS lift with adjuvant lipofilling	The improvement between pre- and postoperative photographs of frontal and three-quarter views. Assessed by two panels consisting of 5 plastic surgeons and 5 medical students.	6-46 months (average > 1 year)	Combined MACS lifting with lipofilling showed better results than MACS lifting alone.	Not mentioned

(continued on next page)

Table 4 (continued)

Reference	Study population	Method of Measurement	Follow-up Period	Results	Complications
Buchanan et al., 2018 ¹¹	<i>n</i> = 30 MACS lifts <i>n</i> = 16 traditional approach facelifts	Procedural duration, concurrent procedures, average follow-up duration, and surgeon satisfaction.	Average follow-up time traditional lift: 171.6 days and MACS lift: 152.8 days.	The MACS technique had a significant reduction in procedural duration, an increase in concurrent procedures, and a decrease in average follow-up duration. There was no significant difference in surgeon satisfaction between the two cohorts. However, there were more occurrences of submental pleating, periocular pleating, temporal pleating, and neck laxity in the MACS group.	Not mentioned
Yu et al., 2020 ¹²	<i>n</i> = 46 elastic thread modified MACS lifts	The mean operating time. The elevation degree of points A and B immediately after surgery. The wrinkle severity ranking scale (WSRS) score by three independent evaluators. Patient satisfaction using Likert scales.	Immediately, 6- and 12-month follow-up	The mean operating time was 114 min. Points A and B showed a lifting effect on both sides. The degree of improvement was significant when compared with the preoperative baseline. Forty-five patients were satisfied immediately after the procedure. At 6 months and 1 year of follow-up, respectively, 41 and 39 patients were satisfied. No obvious facial asymmetry was found.	Five patients presented with mild swelling of the surgical site. Seroma was found in three patients. There were no major complications.

resection of the cervicomental angle can be achieved with a strong vertical pull on the lateral platysma.¹⁷ However, for better results on the neck, extension of the supraplatysmal plane of dissection is indicated (below the mandibular angle), but exposure of the neck with the short-scar technique is limited making the operation technically more difficult.¹⁸ Other limitations of the MACS lift are suture palpability, lack of long-term efficacy and the vertical skin lift which is not aesthetically appropriate for all patients.

Karam et al. also found low complication rates and high levels of patient satisfaction among different kinds of short-scar purse-string facelifts, including the MACS lift.¹⁹ Atiyeh et al. advocate that the ideal candidates for the MACS lift would be younger patients with minimal cervical laxity and feel that short retroauricular incision and undermining would allow better redraping of the cervical skin.¹⁸ These findings are in line with the results of the studies included in this systematic review.

As demonstrated for lipofilling,¹⁰ facelifts combined with other procedures, such as, for example, blepharoplasty, forehead lift etcetera, may lead to higher levels of patient

satisfaction than a facelift procedure alone. This has been confirmed by the study of Gülbitti et al., who concluded that the orbital oval balance principle and orbital oval system of analysis reliably define facial attractiveness: “beauty is around the eyes of the beheld”.²⁰ Therefore, we always should keep in mind that facelifts combined with other procedures, especially around the eyes, enhance patient satisfaction.

In general, most included studies of this review reported positive results concerning satisfaction and complications. In three of the six included studies, the level of evidence was low, with an Oxford Center for Evidence-Based Medicine evidence level of IV.^{7,11,12} The other three studies had an Oxford Center for Evidence-Based Medicine evidence level of III.⁸⁻¹⁰ The outcomes reported in these studies should not be interpreted without caution. These low levels of evidence were caused by poor study designs: four studies were not blinded,^{7,9,11,12} two studies lacked a control group,^{7,12} and two studies did not define all outcomes of interest (i.e. satisfaction reported by the patient and/or surgeon).^{9,11} Studies investigating the same outcomes did not use the

same (validated) outcome measurements which makes it challenging to compare their results.

This systematic review was comprehensive with carefully selected exclusion criteria to ensure that all possible useful studies could be included. The search terms and databases were predetermined and data extraction can be performed reproducibly. The relevance of this study is limited by a risk of bias as a consequence of excluding non-English studies. Then, an important limitation is publication bias, since only published studies were evaluated. The number of studies identified by the literature search was relatively low.

In general, it is not easy to design well-defined, randomized clinical trials with the use of validated outcome measurements and questionnaires for esthetic plastic surgery. Especially, because satisfaction reported by the patient and/or surgeon will always be subjective to bias. Literature on esthetic plastic surgery mainly consists of studies with a small sample size compared with other medical literature, which makes it harder to find significant differences between groups. Most clinical trials compare two different treatment methods, instead of comparing them with a placebo. As a result, it is harder to determine a significant difference in outcomes and the real effect of the investigated methods.

To improve future research concerning the outcomes after esthetic facial procedures we propose the use of a standardized, validated measurement method. The usage of a validated, standardized measurement method will make it easier to compare study results with each other and to find significant differences between groups. The FACE-Q esthetic is an example of such a validated patient-reported outcome measurement method to assess patient satisfaction.²¹⁻²³ Also the validated Rainbow scale for determining the cervicomenal angle, as developed by Van Lande et al., is a perfect reliable method for objective evaluation of the effect of facelift surgery on the neck.²⁴

Conclusion

This systematic review demonstrates that the MACS lift can be considered a minimally invasive facelift procedure with a relatively low complication rate. The procedure, often used in combination with additional procedures, such as lipofilling, results in evident patient and/or surgeon satisfaction. To obtain a significant effect on an aged neck area, additional procedures, are warranted. In order to select the ideal candidate, and to achieve a satisfactory result regarding facial rejuvenation with MACS lifting, it is important to consider its limitations, and acknowledge the need for additional procedures.

Declaration of Competing Interest

None

Funding

None.

Ethical approval

Not required.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjps.2021.11.051.

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