Aesth Plast Surg (2022) 46:1831–1847
https://doi.org/10.1007/s00266-022-02790-1

Complications Associated with Spreader Grafts and Spreader Flaps: A Systematic Review

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Received: 15 November 2021 / Accepted: 15 January 2022 / Published online: 14 February 2022

Abstract

Background and Purpose Spreader grafts and spreader flaps are one of the most common techniques utilized in rhinoplasty surgeries. The aim of this study was to determine the complications, satisfaction, and revision rates associated with spreader grafts and spreader flaps and to compare these two modalities.

Materials and Methods PRISMA guidelines were followed for conducting this systematic review. The authors searched the literature systematically for pertinent materials in PubMed/Medline and Google Scholar. Inclusion criteria of this search included: randomized and non-randomized clinical trials, cohorts, and case series with more than 5 participants on rhinoplasty using spreader grafts or spreader flaps with detailed report either on complications, revision, and satisfaction rates. Furthermore, exclusion criteria included: any cadaveric or non-human study, case reports, technical notes, and review articles.

Results The initial literature search yielded a total of 193 studies. Following screening each paper and implementing the inclusion and exclusion criteria, 40 articles were chosen. In the spreader graft group, from 21 studies reporting complications, 6 of them reported no complication. The most common complications were nasal obstruction, inverted V deformity and open roof deformity, deviation, and infection. In the spreader flap group, from 6 studies reporting any existing complications, 1 reported no complications. Five other studies reported some degree of complications. In terms of revision rate, 10 patients (0.62%) underwent revision surgery after spreader graft placement, while only 2 patients (0.35%) revised surgically in the spreader flap group.

Conclusion These two methods seem to have no significant difference in terms of complication rates, and both are recommended as a choice in middle vault reconstruction when each of their clinical use is indicated.

Level of Evidence IV 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 Spreader graft · Spreader flap · Rhinoplasty · Complications

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Introduction

Despite several challenges and complications, rhinoplasty had been one of the most common plastic surgeries through past decades. Complications such as inverted V deformity, internal nasal valve impairment, and nasal obstruction are among important issues that may lead one to an undesirable revisional surgery [1–3]. During a rhinoplastic procedure, the surgeon should consider midvault preservation, particularly in patients with a narrow roof, thin skin, and weak tissues who are more susceptible to nasal valve collapse [4]. Over the years, several techniques have been described and performed to maintain a stable nasal midvault such as spreader grafts [5], upper lateral cartilage (ULC) suspension[6], butterfly graft [7], upper lateral splay graft [8], and bending the ULC [9].

In the 1980s, spreader grafts were introduced by Sheen et al. [5] for treating patients with short nose syndrome. Later, their usage expanded to a variety of rhinoplastic procedures including nasal tip support or straightening a deviated septum. Placement of a spreader graft between the ULCs and the septum increases the cross-sectional area of the internal nasal valve which is the narrowest part of the airway, but harvesting a cartilaginous graft is a necessity in this method, and inaccuracy in suturing may cause graft displacements. Furthermore, widening of the nasal dorsum might be another unwanted consequence of this technique. In order to overcome the shortcomings, some changes such as pedestal spreader grafts [10], triangular spreader grafts [11], and diced inverted Y-shaped spreader grafts [12] have been made.

Seyhan et al. [9] described an alternative that was simpler and eliminated the need for harvesting (later in 1998 named as spreader flap technique). In this maneuver, the excess height of ULC is bent inwardly and then sutured, so decreasing the valve area would be avoided. Multiple modifications have been described for this method, such as flaring-type spreader flaps, support-type spreader flaps, and partial spreader flaps in order to adjust the width and shape of the middle nasal vault according to patients' individual requirements [10].

Considering the shortcomings and differences in surgeons' opinions, we aimed to assess the complication, satisfaction, and revision rates of the two techniques in a systemic review. Some subjective measurements (NOSE and VAS questionnaire) noted in papers pre- and postoperatively were the secondary purposes.

Materials and Methods

PRISMA Registration

We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for conducting this systematic review (Fig. 1). Our search protocol was specified and registered at PROSPERO (international prospective register of systematic reviews) no. CRD42021239732.

PICO Question

Patient: Patients undergoing reconstructive or cosmetic rhinoplasty using spreader grafts and spreader flaps

Intervention: reconstructive or cosmetic rhinoplasty of nasal dorsum using spreader grafts and spreader flaps

Comparison: the results for spreader grafts were compared with the results for spreader flaps

Outcome: complication rate, satisfaction rate, revision rate, and graft harvesting site comorbidities of the two techniques

Search Strategy

The literature was searched systematically for pertinent materials in PubMed/Medline and Google Scholar up to and including March 2021 with no time and language restrictions. The reference list of included studies was searched manually for potential materials. The following search strategies were used for each database:

1. PubMed/Medline: (107 papers)

("spreader graft"[Title] OR "spreader flap"[Title] OR "cartilage grafts"[Title] OR "cartilaginous graft"[Title] OR "cartilage graft"[Title]) AND ("Rhinoplasty"[Title] OR "Rhinosurgery"[Title] OR "nasal vault"[Title] OR (("nasalance"[All Fields] OR "nasality"[All Fields] OR "nasalization"[All Fields] OR "nasalized"[All Fields] OR "nasally"[All Fields] OR "nose"[MeSH Terms] OR "nose"[All Fields] OR "Nasal"[All Fields] OR "nasals"[All Fields]) AND "vault collapse"[Title]) OR "crooked nose"[Title] OR ("Humpy"[All Fields] AND "nose"[Title]))

2. Google Scholar: (32, 17 papers)

Concept 1: allintitle: allintitle: Rhinoplasty OR Rhinosurgery OR Rhinosurgeries OR "Nasal vault" OR "Nasal vault collapse" OR "Crooked nose" OR "Humpy nose" "Spreader graft"

Concept 2: allintitle: Rhinoplasty OR Rhinosurgery OR Rhinosurgeries OR "Nasal vault" OR "Nasal vault collapse" OR "Crooked nose" OR "Humpy nose" "Spreader flap"

Inclusion and Exclusion Criteria

The inclusion criteria of the current review were as follows:

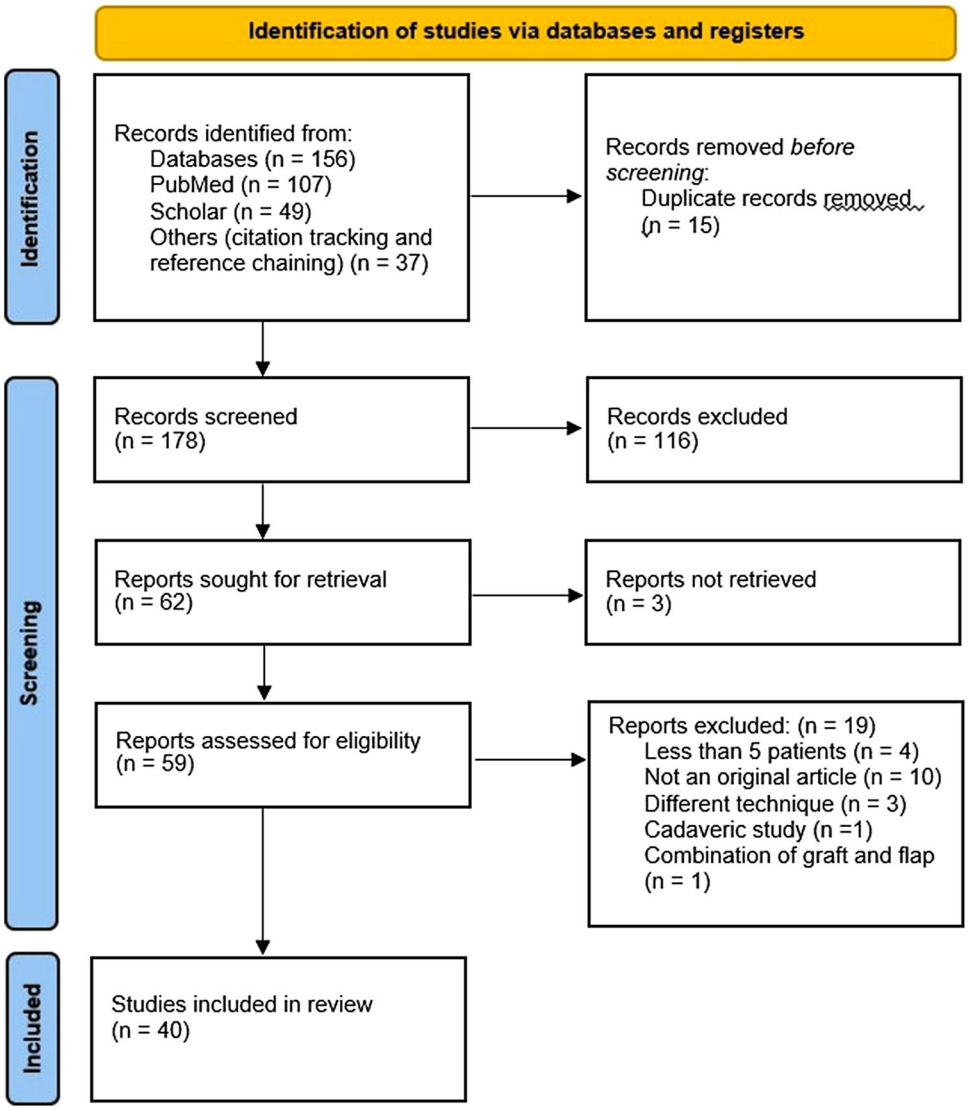

Fig. 1. PRISMA flow diagram for included studies

Randomized and non-randomized clinical trials, cohorts, and case series with more than 5 participants on rhinoplasty using spreader grafts or spreader flaps with detailed report either on complications, revision, and satisfaction rates were included. There was no time limitation for papers, and materials written in English up to April 2021 were included.

The exclusion criteria of the current review were as follows:

Any cadaveric or non-human study, case reports, technical notes as well as review papers were excluded.

Study Selection Process

Two reviewers conducted a duplicate searching process independently in order to determine suitable studies using the inclusion and exclusion criteria. Instances of divergence were resolved by consulting a third investigator. The full-text version of studies was obtained for all titles that appeared to meet the inclusion criteria. After that each paper was studied at least twice by two independent reviewers.

Data Extraction

Whenever applicable, the following data were retrieved from the finally included studies by an author based on a predefined checklist worksheet and supervised by two other authors for accuracy. In case of missing data or any hesitancy, the corresponding author of the study was contacted via emails, up to two emails, as the poorly reported outcomes of included materials could thread the validity of our work. The following data were extracted: first author, year of publication, study type, mean age, sex, number of cases, mean follow-up (range), primary/secondary or tertiary

rhinoplasty, open or closed technique, main outcomes, satisfaction rate (percent), reported complications.

Risk of Bias Assessment

Quality assessment of our included studies was done independently by two reviewers, and instances of divergence were resolved by consulting a third investigator. We used Newcastle Ottawa scale [13] for grading cohort studies and Cochrane ROB2 tool [14] for clinical trials whether they were randomized or not [15] (Tables 6 and 7).

Result

Study Selection

The initial literature search yielded a total of 193 studies. Following screening title and abstract and eliminating duplicates, 131 papers excluded and 62 papers left for full-text screening. Three full text did not retrieve, and among 59 remained studies, we excluded 19 papers due to low number of cases, not to be an original article, different technique, combination therapy, or cadaveric study. Finally, 40 studies were included, as reported in the PRISMA flow diagram.

Study Characteristics

Spreader grafts were used in 28, and spreader flaps were used in 8 studies. Four papers discussed both spreader grafts and spreader flaps.

In the spreader graft group, a total of 1596 patients were enrolled in this review that 406 (25.4%) of them were treated through an endonasal approach, while the rest of the surgeries were performed open. Except for 92 patients who were treated with synthetic material (porous polyethylene), the other patients' spreader grafts were made from their cartilaginous tissues (mostly septal cartilage). In total, 52% of them were females, with a mean age of 31.9 years. The mean follow-up period after surgery was 13.3 months (3 months to 5 years range). Also in the spreader flap group, a total of 570 patients were enrolled that all were treated through an open approach except 39 (6.84%) who were treated endonasal. In total, 66% of them were females (2 studies did not mention the sexuality of their patients [16, 17]), with a mean age of 27.04 years old (4 papers did not mention the mean age). The mean follow-up period after surgery was 13.5 months. Table 2 shows brief details of our included papers' characteristics.

In the case of primary or revision rhinoplasty, in the spreader graft group, 5 studies did not mention their patients' characteristics [12, 17–20]. Of 1410 remained patients, 233 had undergone revision surgery and the rest were primary. In the spreader flap group, from 9 studies reporting surgical phase, only 2 studies included revision cases (13 patients). Tables 1 and 2 present a summary of our included papers' characteristics.

Patient Satisfaction

In the spreader graft group, 20 studies noted nothing about their patients' satisfaction after surgery. Among 12 other studies, the mean satisfaction rate was 93.7%. Also in the spreader flap group, 6 studies did not notice anything about their patients' satisfaction, while in the other 6 papers, the mean satisfaction rate was 94% which was not different from the spreader graft group significantly.

Complications

From all included papers, 13 studies did not mention anything about complications [12, 19, 21–31] in the spreader graft group. From 22 studies reporting complications, 6 of them reported no complications [11, 32–36], and in other studies, reported complications are as mentioned in Table 3. The most common complications were nasal obstruction (in 9 patients), different kinds of deformity such as inverted V deformity and open roof deformity (in 9 patients), deviation (in 7 patients), and infection (in 7 patients). Other noticeable complications mentioned were irregularity, extrusion, overcorrection, hematoma, columella scar, nasal tip rotation, erythema at the auricular donor site, and epistaxis.

In the spreader flap group, from 6 studies reporting any existing complications, 1 reported no complications [37]. Other studies' postsurgical complications are noticed in Table 3.

In a study [38], 1 aesthetically narrow midvault was reported, while dorsum fullness (in 3 patients) and deviation (in 1 patient) were seen in another record [16]. One paper mentioned nasal breathing problems in 12 of their included patients due to rhinitis and pinch nose [39]. Ozmen et al. [40] reported synechiae in 8 of their patients postoperatively. The other study compared respiratory complications in both spreader graft and spreader flap groups [17].

Revision Rate

Ten patients (0.62%) underwent revision surgery after spreader graft placement, while only 2 patients (0.35%) revised surgically in the spreader flap group.

Table 1. The spreader graft groups' characteristics

	Authors	Year	Study type	Number of cases (included)	Female number / mean age	Mean follow-up (month)	Open or closed	Primary or revision rhinoplasty	Main results	Satisfaction rate (%)
1	Yong Ju Jang et al. [26]	2007	Single-arm uncontrolled cohort	33 (33)	6 33	3	Open	32 primary 1 revision	All the cases had good aesthetically dorsal line, opening of internal nasal valve area and good septal support, which was weakened by the removal of deviated septum	100
2	Young Hyo Kim et al. [43]	2011	Non-randomized clinical trial	58 (29)	9 NR	64	Open	Primary	The patients in group A showed more decrease of nasal obstruction by visual analog scale and more improvement of minimal cross-sectional area as compared with those in group B	93
3	Mahmoud Omranifard et al. [44]	2013	Randomized clinical trial	50 (25)	6 35.6	3	Open	Primary	Both techniques were beneficial in rhinoplasty and they could provide enough internal nasal valve support	NR
4	Alberto Scattolin et al. [36]	2013	Single-arm uncontrolled cohort	49 (49)	20 27.8	12.2	49 closed	15 primary 34 revision	47 (98%!) patients displayed an improvement of their nose breathing function. before and 6 month after surgery, a significant improvement in NOSE scores was found	NR
5	M Samaha et al. [55]	2015	Single-arm uncontrolled cohort	100 (100)	83 31.2	9.3	100 closed	73 primary 27 revision	Among 100 cases, only 4 patients had some kind of complication No patient reported nasal obstruction and 97% reported improved nasal breathing	NR
6	Carlos Oscar Uebel et al. [56]	2017	Single-arm uncontrolled cohort	34 (34)	28 40	24	Open	Primary	94% Reported a better airflow and 91% reported a very good aesthetic results 2 years postoperatively	91
7	Jason Talmadge et al. [30]	2018	Non-randomized clinical trial	50 (50)	17 41	12	29 closed	Primary	Improvement in NOSE scores recorded preoperatively and postoperative follow-up in both groups as well as difference in operative times	100
8	Burak Mustafa Taş et al. [42]	2020	Randomized clinical trial	50 (24)	16 26.88	6	Open	Primary	Postoperative values were significantly lower than preoperative values in both groups. No significant difference was observed between the groups according to NOSE, SNOT-22 and VAS scores	NR
9	Robert F. Andre et al. [32]	2004	Single-arm uncontrolled cohort	89 (89)	29 38.6	12.2	89 closed	48 primary 41 revision	Of a total of 120 sides operated on, 53 sides (44%) were judged as optimal and 53 (44%), as improved. On 13 sides (11%) no change was noted. On 1 side (1%) the postoperative situation was judged as worse	NR
10	Armando Boccieri et al. [48]	2005	cohort	60 (60)	35 32	17	15 closed	primary	All the patients reported improvement in functional and esthetic problems, with no complications related to the preoperative features.	98
11	Martyn Mendelsohn[57]	2005	Single-arm uncontrolled cohort	41 (41)	15 34	15	Open	21 primary 20 revision	Every patient had substantial improvement in the straightening of the middle third of the crooked nose and the airway in one procedure	NR

Table 1. continued

	Authors	Year	Study type	Number of cases (included)	Female number / mean age	Mean follow-up (month)	Open or closed	Primary or revision rhinoplasty	Main results	Satisfaction rate (%)
12	Ali Gurlek et al. [34]	2006	Single-arm uncontrolled cohort	15 (15)	NR 32	16	3 closed	15 revision	Neither complication nor recurrence of airway obstruction occurred	NR
13	Jose´ M. Palacin et al. [35]	2007	Single-arm uncontrolled cohort	41 (41)	32 27	12	Open	Primary	All showed preserved nasal length after surgery with well-proportioned facial features. There was no evidence of postoperative nasal shortening after 12 months	100
14	Alyssa J. Reiffel et al. [58]	2011	Non-randomized clinical trial	18 (18)	NR 38	27.5	Open	18 revision	Neither observer was able to ascertain any difference in appearance or functional performance between the 2 groups. All patients had resolution of inverted "V" deformities, and no patient complained of an excessively wide nasal dorsum	100
15	Victor D. de Pochat et al. [31, 59]	2012	Single-arm uncontrolled cohort	20 (20)	14 31	11.5	Open	Primary	Evaluation showed significant improvement of breathing quality and a mean MCA area of the left side. There was no significant change of the mean MCA of the right side or nasal patency between pre-op and postop evaluation	NR
16	Donald B. Yoo et al. [31]	2012	Single-arm uncontrolled cohort	41 [41]	22 32	20	41 closed	23 primary 18 revision	The endonasal approach to placement of spreader grafts for nasal valve reconstruction is effective at relieving nasal obstruction due to internal nasal valve dysfunction	100
17	Mir Mohammad Jalali [45]	2014	Non-randomized clinical trial	220 (87)	54 29.9	5	Open	Primary	After rhinoplasty, nasal airway resistance decreased in 46 patients of spreader grafts group. The median nasal airway resistance difference of spreader grafts groups was 0.027 Pa/ml/s	NR
18	Bree Erickson et al. [33]	2016	Single-arm uncontrolled cohort	17 (17)	1 34.5	4	17 closed	Primary	Patients had significant improvement for INV collapse grading, cross-sectional area, NOSE, and SNOT-22 scores in both the early and intermediate follow-up	NR
19	Murat Sertan Sahin et al. [11]	2016	Single-arm uncontrolled cohort	22 (22)	9 21.4	3	Open	Primary	Average of NOSE scale was 64.3 before surgery and it was reduced to 17.9 3 months after surgery. Average VAS score was 2.6 before surgery and it increased to 8.1 at postoperatively.	NR
20	Marlen Mamanov et al. [28]	2017	Randomized clinical trial	30 (15)	6 29.8	6	Open	Primary	Performing spreader graft technique in SRP surgery can prevent the narrowing of the internal nasal valve area after surgery and maintain adequate airway for respiration.	NR
21	Paul et al. [41]	2018	Single-arm uncontrolled cohort	38 (38)	20 36.9	3	30 closed	33 primary 5 revision	The cross-sectional area in closed and open rhinoplasty patients increased significantly. There was a functional improvement in all presented cases using the NOSE scale evaluation	100
22	Atighechi et al. [18]	2018	Randomized clinical trial	210 (70)	41 25.61	6	Open	NR	Nasal obstruction had no significant difference before and after rhinoplasty and no significant difference was observed between spreader graft and mattress sutures, but significantly better results than control group	NR
23	Demir [60]	2019	Single-arm uncontrolled cohort	16 (16)	10 24.2	6	Open	primary	Average RDA was 7.538 and the TDA was 5.088 in the study group. The RDA value showed significant decrease after surgery in the study group. The changes at TDA were also significant	81

Table 1. continued

	Authors	Year	Study type	Number of cases (included)	Female number / mean age	Mean follow-up (month)	Open or closed	Primary or revision rhinoplasty	Main results	Satisfaction rate (%)
24	*Shafaeei et al.* [17]	*2019*	*cohort*	*130* (69)	*NR* NR	*NR*	*Open*	*NR*	*The use of spreader graft technique increases the incidence of nasal hump while the use of spreader flap technique results in an increase in the incidence of obstructive sleep apnea*	*NR*
25	*Hassanpour et a. l*[23]	*2016*	*Non-randomized clinical trial*	*50* (25)	*19* 29.64	*NR*	*Open*	*20 primary* 5 *revision*	*Total nasal airways resistance increased significantly by both spreader graft and autospreader flap techniques, but the difference was not statistically significant. The total nasal flow significantly increased in both methods*	*86*
26	El-Sherif et al. [12]	2019	Single-arm uncontrolled cohort	24 (24)	21 28	12	Open	NR	There was significant improvement in both groups but more in modified Spreader Graft Group	72
27	*ElBestar et al.* [21]	*2020*	*Randomized comparative trial*	*30* (15)	*8.5* 25.1	*7*	*15 closed*	*primary*	*In both groups significant improvement in both functional and aesthetic outcome was obtained. There was no statistically significant difference in outcome between both groups*	*NR*
28	Goffart et al. [61]	2015	Cohort	420 (420)	NR NR	36	18 closed	378 primary 42 revision	No evidence of postoperative displacement was noted. Symmetry of the middle third of the nose and adequacy of aesthetic brow tip lines were obtained in the vast majority of the patients	NR
29	Ingels [25]	2008	Single-arm uncontrolled cohort	15 (15)	NR NR	NR	Open	Primary	The mean subjective patency increased. None of the patients reported a change in broadness of the supratip region. The mean NDW of the intercanthal distance increased postoperatively	NR
30	*Sowder et al.* [19]	*2020*	*Cohort*	*26* (13)	*9* 37.4	*24*	*Open*	*NR*	*No difference was found in mean postoperative NOSE score, total NOSE score improvement or percentage of improvement in NOSE score between groups.*	*NR*
31	Stacey et al. [20]	2009	Cohort	34 (10)	7 29	3	Open	NR	Patients undergoing both procedures demonstrated an overall improvement in their nasal breathing. Significant differences in improvement were observed for patients in the categories of postoperative snoring, sleep, and continuous positive airway pressure use	NR
32	Standlee et al. [29]	2017	Cohort	109 (74)	14 33	6.3	Open	67 primary 7 revision	Surgery reduced NOSE scores. The mean differences in NOSE score across all time points after septoturbinoplasty and septorhinoplasty with spreader graft placement were 40 and 49, respectively.	NR

Studies which are discussing both groups are italicized

Table 2. The spreader flap groups' characteristics

	Authors	Year	Study type	Number of cases (included)	Gender (female number)/ mean age	Mean follow-up (month)	Open or closed	Primary or revision rhinoplasty	Main results	Satisfaction rate (%)
1	Omer Faruk Kocak et al. [27]	2018	Randomized clinical trial	36 (12)	10 27.31	3	Open	Primary	Postoperative values of NOSE were higher than preoperative, preoperative VAS scores were lower than postoperative, and nasal valve angles were found increased	100
2	Wael Khamis Hussein et al. [24]	2014	cohort	22 (22)	12 24.68	9	Open	NR	Significant improvement in the nasal valve angle width was found in both groups. Subjective evaluation using NOSE scale scores showed improvement in both groups	100
3	Gorgülü et al. [22]	2015	Single-arm uncontrolled cohort	64 (64)	45 24	18	Open	Primary	Postoperative feedback from all patients was positive. No patient had any palpable dorsal irregularities. Inspiratory and expiratory NARs were significantly lower	100
4	Gruber et al. [38]	2007	Single-arm uncontrolled cohort	25 (25)	18 NR	15	4 Closed	Primary	The spreader flap almost always reconstructed the middle third of the nose. It was easy to execute in the open approach but difficult in the closed approach	88
5	*Shafaeei et al.* [17]	*2019*	*Cohort*	*130* *(61)*	*NR* *NR*	*NR*	*Open*	*NR*	*The use of spreader graft technique increases the incidence of nasal hump, while the use of spreader flap technique results in an increase in the incidence of obstructive sleep apnea*	*NR*
6	*Hassanpour et al.* [23]	*2016*	*Non-randomized clinical trial*	*50* *(25)*	*18* *24.65*	*NR*	*Open*	*23 primary* *2 revision*	*Total nasal airways resistance increased significantly by both spreader graft and autospreader flap techniques, but the difference was not statistically significant. The total nasal flow significantly increased in both methods*	*86*
7	*ElBestar et al.* [21]	*2020*	*Randomized comparative trial*	*30* *(15)*	*8.5* *25.1*	*7*	*15 Closed*	*Primary*	*In both groups significant improvement in both functional and aesthetic outcome was obtained. There was no statistically significant difference in outcome between both group*	*NR*
8	Elnaggar et al. [16]	2020	Non-randomized clinical trial	40 (40)	NR NR	9	Open	Primary	The results are satisfactory in most cases regarding the aesthetic and functional outcomes. Using auto-spreader flaps is shown to be simple, reproducible and effective in shaping the midvault while keeping the internal valve intact	90
9	Manavbaş¸I et al. [39]	2011	cohort	169 (81)	53 NR	17	Open	158 primary 11 revision	All the patients with breathing problems described significant relief of their symptoms. Even the patients without breathing problems preoperatively note that their nasal breathing was improved	NR
10	Ozmen et al. [40]	2008	Single-arm uncontrolled cohort	180 (180)	114 28.34	20	20 Closed	Primary	All patients but 9 stated significantly improved nasal breathing. There was no inverted-V deformity or middle-vault narrowing observed	NR
11	Saedi et al. [37]	2014	Randomized clinical trial	66 (32)	22 25.56	NR	Open	Primary	Despite the worse preoperative esthetic VAS in the spreader flap group, the postoperative results in both groups did not have significant differences	NR
12	*Sowder et al.* [19]	*2020*	*Cohort*	*26* *(13)*	*9* *38.4*	*24*		*NR*	*No difference was found in mean postoperative NOSE score, total NOSE score improvement* *or percentage of improvement in NOSE score between groups*	*NR*

Studies which are discussing both groups are italicized

Table 3. All included studies' reported complications

Author, year of publication, number of cases	Rates of complications							
	Extrusion	Infection	Deviation (graft displacement)	Overcorrection	Hematoma	Irregularity	Others	Revision
Gruber et al. [38], 2017, 25*	0	0	0	0	0	0	Aesthetically narrow middle vault: 1	0
Shafaeei et al. [17], 2019, 130**	0	0	0	0	0	0	Obstructive sleep apnea and other respiratory complications	0
Elnaggar et al. [16], 2020, 40*	0	0	1	0	0	0	Fullness on the dorsum: 3	1
Manavbas et al. [39], 2011, 169*	0	0	0	3	0	0	Nasal breathing problems: 12. pinch nose: 3, and allergic rhinitis: 9	1
Saedi et al. [37], 2014, 66*	0	0	0	0	0	0	0	0
Ozmen et al. [40] 2008, 180*	0	0	0	0	0	0	Synechiae: 8 (1 bilateral, 7 unilateral)	0
Goffart et al. [61], 2018, 420	0	1	0	0	0	0	**0**	0
Atighechi et al.[18], 2018, 210	0	0	0	0	0	Inverted V deformity: 6	Nasal obstruction: 6	0
Demir [60], 2019, 16	0	0	0	0	0	I-shaped deformity: 1	0	1
Stacey et al. [20], 2009, 78	0	0	0	0	0	0	Inferior turbinate hypertrophy: 8	0
Kim et al. [43], 2011, 58	1	0	0	0	0	0	0	1
Mahmoud Omranifard et al. [44], 2013, 50	0	0	0	0	0	0	Medical examination: 2 patients had mild obstruction Clinical complaints of obstruction: 1 patient had mild obstruction.	0
Alberto Scattolin et al. [36], 2013, 49	0	0	0	0	0	0	0	0
Samaha et al. [55], 2015,100	0	0	0	0	1	3	0	0
Uebel et al. [56], 2017, 34	0	0	4	0	0	0	Supra-tip deformities: 2 Columella scar revision: 1	3
Taş et al. [42], 2020, 50	0	0	0	0	0	1	Nasal tip rotation increasing:1	4
Andre et al. [32], 2004, 89	0	5	0	0	0	0	0	0
Armando Boccieri et al. [48], 2005, 60	0	0	1	0	0	0	0	1
Martyn Mendelsohn [57], 2005, 41	0	0	0	0	0	0	0	0
Ali Gurlek et al. [34], 2006, 15	0	0	0	0	0	0	0	0
Palacin et al. [35], 2007, 41	0	0	0	0	0	0	0	0
Reiffel et al. [58], 2011, 18	0	1	0	0	0	0	Erythema at the auricular donor site: 1	0

Table 3. continued

Author, year of publication, number of cases	Rates of complications							
	Extrusion	Infection	Deviation (graft displacement)	Overcorrection	Hematoma	Irregularity	Others	Revision
de Pochat et al. [59], 2012, 20	0	0	0	0	0	0	Synechiae: 2 patients septal granuloma: 1	0
Mir Mohammad Jalali [45], 2014, 220	0	0	2	0	0	0	Synechiae: 4	0
Bree Erickson et al. [33], 2016, 17	0	0	0	0	0	0	0	0
Murat Sertan Sahin et al. [11], 2016, 22	0	0	0	0	0	0	0	0
Paul et al. [41], 2018, 38	0	0	0	0	0	0	Epistaxis: 1	0

*Spreader flap group studies

**Studies discussed both spreader flap and spreader graft

Subjective Measurements

In the spreader graft group, 9 studies measured their patients' nasal obstruction symptom evaluation (NOSE) scores pre- and postoperatively [11, 19, 21, 29, 30, 33, 36, 41, 42]. All of them reported an improvement in postoperative evaluations (Table 4). In the spreader flap group, 4 papers reported NOSE scores pre- and postoperatively [19, 21, 24, 27]. They also noted an improvement in the postoperative scores compared with the preoperative ones (Table 5).

In the spreader graft group, 8 studies used visual analog scale (VAS) questionnaire to assess their patients' opinions about the result of surgery [11, 21, 23, 25, 28, 42–44]. Six papers reported an improvement in mean postoperative VAS scores. One of them reported no significant difference before and after rhinoplasty [44]. One remained study reported overall improvement though there were unsatisfied patients [23] (Table 4). In the spreader flap group, 4 papers reported VAS scores pre- and postoperatively [21, 23, 27, 37]. Three studies reported an improvement in the mean postoperative scores, while one study [23] noted unsatisfaction in some of their patients and satisfaction in most of them (Table 5).

Discussion

This article is the first systematic review that sought to compare complication and satisfaction rates and subjective measurements between spreader grafts and spreader flaps in patients undergoing rhinoplasty. Our systematic review revealed that there is not a significant difference among the abovementioned factors when comparing spreader grafts and spreader flaps (Tables 6 and 7).

Numerous reasons justify the need for rhinoplasty, among which may be found septal deviation or deformation most commonly. Such abnormalities are frequently associated with functional complications that necessitate a combination of cosmetic and functional rhinoplasty [23]. However, functional and cosmetic features of the nose seem to be closely intertwined; hence, utilizing the correct surgical approach will technically achieve the desired functional and cosmetic outcomes simultaneously [5].

Spreader grafts are one of the long-established techniques utilized in rhinoplasty surgeries. This technique incorporates moving the upper lateral cartilages away from the nasal septum with grafts, therefore increasing the angle between the upper lateral cartilages and septum. The use of grafts improves the function of the nasal cavity and renders aesthetically pleasing contours to the middle nasal vault [45]. Despite its routine use in rhinoplasty procedures, this technique may lead to few complications, one of which

Table 4. The spreader graft groups' subjective measurements

First author, number of patients	Nasal obstruction symptom evaluation (NOSE)	Visual analog scale (VAS)
Kim 29	NR	Functional results VAS of nasal obstruction was improved in both groups 1 year after the surgery. Patients in group A had more improvement of VAS compared with group B, which was statistically significant (group A: 7.8 ± 0.8 to 4.4 ± 1.0 vs. group B: 8.0 ± 0.9 to 3.7 ± 0.9, $P = 0.02$)
Omranifard 25	NR	Statistically based on clinical complaints, nasal obstruction had no significant difference before and after rhinoplasty
Scatolin 49	When comparing patients' answers to the NOSE questionnaire before and 6 month after surgery, a significant improvement in NOSE scores was found: preoperative 76.79 (± 18.57) versus 14.38 (± 10.92) postoperative	NR
Talmadge 50	All patients improved in NOSE scores postoperatively, except for a single patient who increased from 60 up to 65 despite reporting subjective improvement in his postoperative evaluations	NR
Tas 24	Mean preoperative and postoperative NOSE scores were 13.42 ± 4.32 and 3.58 ± 2.63, respectively	Mean preoperative and postoperative VAS scores were 7.38±1.86 and 2.04±1.12, respectively, and a significant improvement was observed postoperatively
Erickson 17	Patients had significant improvement for NOSE scores in both the early and intermediate follow-up	NR
Sahin 22	Average of NOSE scale was 64.3 before surgery and it was reduced to 17.9 3 months after surgery	Average visual analog scale score was 2.6 before surgery and it was 8.1 3 months after surgery indicating a better breathing sensation.
Mamanov 15	NR	For group II patients, postoperative mean VAS scores revealed a statistically significant reduction compared with preoperative values on both the sides of the nasal cavity
Paul 38	Average of NOSE scale was 13.5 before surgery and it was reduced to 4.6 after surgery	NR
Ingels 15	NR	Patients expressed the feeling that their nasal airway had doubled, from 3.2 to 6.6 on a VAS
Standlee 74	The mean differences in NOSE scores across all postoperative time points after rhinoplasty with spreader graft placement were 49, respectively	NR
Hassanpour 25	NR	Aesthetically, 8 subjects were complete satisfied, 14 were partially satisfied, and 3 subjects were unsatisfied Functionally, 17 subjects were complete satisfied, 6 were partially satisfied, and 2 subjects were unsatisfied
Elbester 15	A showed significant improvement in the postoperative scores compared with the preoperative ones. The mean NOSE score preoperatively was 52.67±30.3, while postoperatively, it was 20.33±14.2	Group A showed significant improvement in the patient's satisfaction regarding the aesthetic results within group A giving a mean VAS of 2.87 ±0.64 instead of 0.60 ±0.74
Sowder 13	We found a statistically significant improvement in the postoperative mean (SD) NOSE scores compared with the preoperative scores in the spreader graft group	NR

Table 5. The spreader flap groups' subjective measurements

First author, number of patients	Nasal symptom obstruction evaluation (NOSE)	Visual analog scale (VAS)
Saeidi 32	NR	Mean preoperative and postoperative VAS (patients' satisfaction scores) were 4.43 ± 2.49 and 8.38 ± 1.6, respectively Mean preoperative and postoperative VAS (nasal obstruction scores) were 5.57 ±2.51 and 2.56 ±0.52, respectively
Hussein 22	Subjective evaluation using NOSE scale scores showed improvement in both groups	NR
Kocak 12	Mean preoperative and postoperative NOSE scores were 26.8 ± 18.4 and 10.5 ± 7.4, respectively	Mean preoperative and postoperative VAS scores were 4.00 ± 1.9 and 8.8 ± 0.7, respectively
Hassanpour 25	NR	Aesthetically, 10 subjects were complete satisfied, 11 were partially satisfied, and 4 subjects were unsatisfied. Functionally, 15 subjects were complete satisfied, 7 were partially satisfied, and 3 subjects were unsatisfied
Elbester 15	.The mean NOSE score preoperatively was 55.36 ±22.1, while postoperatively it was 23.21±14.7	Group B showed significant improvement in the patient's satisfaction regarding the aesthetic results within group B giving a mean VAS of 3.07 ±0.70 instead of 0.57 ±0.64
Sowder 13	We found a statistically significant improvement in the postoperative mean (SD) NOSE scores compared with the preoperative scores in the spreader flap group (63.5 [23.5]; 95% CI, 49.3-77.6)	NR

includes falling of the graft tissue into the mucoperichondrial pocket and therefore resulting in the movement of the grafts away from their original desired position [26].

In the spreader flap technique, a specific length of perichondrium of the upper lateral cartilages is spread over the whole length of nasal cartilages and the conjunction of the lateral cartilages to the nasal bones is locally released. Nevertheless, this technique also comes with few complications including excessively wide middle nasal vault, an asymmetry in nasal cartilages, the collapse of lateral walls, and reduction of internal nasal valve angle which results in nasal obstruction [46].

While both spreader grafts and flaps can achieve the same results, each has its advantages and disadvantages. Spreader grafts can provide distinct designs and shapes in order to achieve the desired objective. Furthermore, they can be placed into pockets created on either side of the dorsal septum. However, adequate grafting material is required in order to design such grafts. Conversely, spreader flaps provide more limited volumes, which are determined by the thickness of the dorsal edges of the upper lateral cartilages. Moreover, sufficient upper lateral cartilage excess must remain following cartilaginous hump removal in order to provide the adequate inward fold of the cephalic edge of the upper lateral cartilage for flap construction. The supporting literature suggests that 2 mm of residual excess upper lateral cartilage after septal cartilage reduction is considered sufficient for performing spreader flap [38, 47–49]. Furthermore, spreader flaps need to be fixed in place using sutures, while spreader grafts can be exempted from this necessity. Furthermore, their use spares the excess cartilage that is otherwise trimmed [50, 51]. Numerous researches have described the indications for these two techniques, including widening of the internal nasal valve, correction of deviated dorsal septum, correction of unilateral asymmetry due to inward curvature of one upper lateral cartilage, preventing delayed contracture deformity of the upper lateral cartilage, and serving as a cantilever to lengthen an overly rotated lobule [5, 52–54].

In 2020, a panel of internationally recognized rhinoplasty surgeons participated in a two-part organized communication method summit. The summit transcription was analyzed by thematic content analysis in order to develop a survey encompassing clinical scenarios for primary rhinoplasty. The following key anatomical features were utilized as selection criteria for preferred approach to midvault reconstruction: size of the dorsal hump reduction, width of the midvault relative to the upper vault, presence of dorsal angulation, and presence of nasal obstructive symptoms. In cosmetic scenarios with large dorsal hump reduction in patients with a straight dorsal septum undergoing dorsal hump reduction of greater than 2 mm, the consensus of

Table 6. Risk of bias assessment for cohort studies

Author, year	Selection				Comparability	Outcome			Overall quality
	Representa-tiveness of the exposed cohort	Ascertainment of exposure	Selection of the non-exposed cohort	Outcome of interest was not present at start	Study controls for complications or satisfaction rate	Assessment of outcome	long enough follow-up (≥3month)	Adequacy of follow-up (<10% lost)	
Jang et al 2007	*	*	NR	*	*	*	*	*	Good
Scattolin et al 2013		*	NR	*	*	*	*	*	Fair
Samaha et al 2015	*	*	NR	*	*	*	*	*	Good
Uebel et al 2017	*	*	NR	*	**		*		Fair
Andre et al 2004	*	*	NR	*	*		*	*	Fair
Boccieri et al 2005	*	*	*	*	**	*	*	*	Good
Mendelsohn 2005	*	*	NR	*	*	*	*	*	Good
Gurlek et al 2006	*	*	NR	*	*	*	*	*	Good
Palacin et al 2007	*	*	NR	*	**	*	*	*	Good
De Pochat et al 2012		*	NR	*	*	*	*	*	Fair
Yoo et al 2012	*	*	NR	*	*	*	*	*	Good
Hussein et al 2014	*	*	*	*	*	*	*	*	Good
Erickson et al 2016		*	NR	*	*	*	*		Fair
Sahin et al 2016	*	*	NR	*	*	*	*	*	Good
Paul et al 2018	*	*	NR	*	**	*	*	*	Good
Gorgülü et al. 2015	*	*	NR	*	*	*	*	*	Good
Gruber et al. 2007	*	*	NR	*	**	*	*	*	Good
Demir 2019	*	*	NR	*	**	*	*	*	Good
Shafaeei et al. 2019	*	*	*	*	*	*			Poor
Goffart et al. 2018	*	*	*	*	*	*	*	*	Fair
Ingels 2008	*	*	NR	*		*			Poor
Manavbaş¸I et al. 2011	*	*	*	*	*		*	*	Fair
Ozmen et al. 2008	*	*	NR	*	*	*	*	*	Fair
Sowder et al. 2017	*	*	*	*		*	*	*	Fair

Table 6. continued

Author, year	Selection				Comparability	Outcome			Overall quality
	Representativeness of the exposed cohort	Ascertainment of exposure	Selection of the non-exposed cohort	Outcome of interest was not present at start	Study controls for complications or satisfaction rate	Assessment of outcome	long enough follow-up (≥3month)	Adequacy of follow-up (<10% lost)	
Stacey et al. 2009	*	*	*	*	*	*	*	*	Good
Standlee et al. 2017	*	*	*			*	*	*	Poor

Maximum star for selection bias is 4, comparability bias is 2, and outcome bias is 3

NR: single-arm uncontrolled cohorts which do not have non-exposed cohort group

panel of experts was to use spreader flaps for midvault reconstruction. Conversely, for patients who have dorsal septal angulation, there was a split preference in the method of midvault reconstruction depending on the middle vault width. Preferred methods for these scenarios were asymmetric spreader flaps or asymmetric spreader grafts. In cosmetic scenarios with small dorsal hump reduction in patients with a straight dorsal septum undergoing dorsal hump reduction less than 2 mm, the panel majority preference was the use of spreader grafts. For patients with small dorsal hump reduction with dorsal septal angulation, the general consensus was to use asymmetric spreader grafts for equal and narrow middle vault widths. Furthermore, in cases with a wide midvault, there was still majority preference for the use of asymmetric spreader grafts. In functional scenarios with both small and large dorsal hump reduction with either static or dynamic valvular stenosis, the dominant preference among specialists was the use of spreader grafts [47].

Another issue related to spreader grafts is that weak upper lateral cartilages may not be supportive enough to provide structural stability equivalent to spreader grafts. To our knowledge, no study has specifically investigated the strength/stiffness of ULC's when used in functional cases.

We sought to review and compare the cardinal indicators of complications among these two approaches including extrusion, irregularity, hematoma, overcorrection, deviation (graft displacement), infection, and revision rates. As can be concluded from the results section, in the case of appropriately selected patients, there is not any significant difference between spreader graft and spreader flap techniques in terms of complications.

Comparing the patients' satisfaction rates following the surgery, the majority of the articles stated very high satisfaction rates among both spreader flap and spreader graft techniques; however, the number of articles comparing these two was limited. ElBestar et al. [21] analyzed the improvement in postoperative patients' satisfaction using the visual analog scale (VAS), and the difference was found to be statistically insignificant. Furthermore, Hassanpour et al. [23] compared the satisfaction rates, in which the differences were found to be statistically insignificant.

In terms of comparing subjective measurements using the NOSE scores pre- and postoperatively, again the majority of articles in both approaches showed improvements in this score postoperatively. Two papers [19, 21] compared the pre- and postoperative NOSE score in spreader flaps and spreader grafts in which both groups showed a significant improvement; however, the intergroup comparison depicted no significant difference.

Very few studies have compared the complication rates between these two techniques. Shafaeei et al. [17] reported that only in the incidence of obstructive sleep apnea there is a significant difference between the two groups in terms of respiratory complications, with the patients treated with spreader graft technique showing a lower incidence than those treated with spreader flap technique. However, concerning other respiratory complications, no significant difference was observed between these two groups.

A considerable limitation of this review is the paucity of the studies which report any complications or solely compare the complications among these two modalities. The results of our study reflect what has been reported and may not reflect what exactly happens in clinical practice. Also, the risk of bias cannot be completely overlooked due to multiple reasons including the fact that only English literature has been reviewed in this article. Besides, the short follow-up period in some of the articles can lead to a neglect of a significant portion of valuable data regarding long-term complications. We are also aware of the fact that some of the included studies slightly vary from the original intended methods; however, these modifications do not seem to play an important role in the final results; therefore, the decision was made to include these studies as

Table 7. Risk of bias assessment for clinical trials

Author, year	Risk of bias arising from the randomization process	Risk of bias due to deviations from the intended interventions	Missing outcome data	Risk of bias in measurement of the outcome	Risk of bias in selection of the reported result	Overall risk of bias
Kim et al. 2011	–	L	L	L	H	H
Omranifard et al. 2013	L	L	L	L	L	L
Talmadge et al. 2018	–	S	L	L	L	S
Kocak et al. 2018	L	L	L	L	L	L
Taş et al. 2020	L	L	L	L	L	L
Reiffel et al. 2011	–	L	L	L	S	S
Jalali 2014	–	S	L	L	L	S
Mamanov et al. 2017	L	S	L	L	L	S
Atighechi et al. 2018	L	L	L	L	L	L
Hassanpour et al. 2016	L	L	L	L	L	L
El-Sherif et al. 2019	S	L	L	L	L	S
ElBestar et al. 2020	L	L	L	L	L	L
Elnaggar et al. 2020	–	L	L	L	S	S
Saedi et al. 2014	L	L	L	L	L	L

L: low risk of bias, S: some concern, H: high risk of bias

well. To the best of our knowledge, this study is the most comprehensive study to date that has assessed the complication rates of these two techniques based on different indicating factors with reliable statistical tools. Finally, it should be noted that to improve statistical efficiency, further high-quality studies employing larger subject pools, longer follow-ups, and more comprehensive assessments should be conducted in the future.

Conclusion

Based on our systematic review of the complications as reported in the literature, spreader flaps and spreader grafts seem to have no significant difference in terms of complication and revision rates. Of course, overall reporting of complications is relatively deficient, but both techniques can restore the integrity of the middle vault in properly selected cases with no expectation for greater or lesser incidence of complication.

Acknowledgement None.

Funding None.

Declarations

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

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