

Choanal Atresia Repair With Stents and Flaps: A Systematic Review Article

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Abstract

Background: Choanal Atresia is an obliteration by an atretic plate of the posterior choanae due to a failure of the bucconasal membrane to rupture. The insertion of stents post choanal atresia repair is familiar. Still, there are limited studies in the literature that specify the time to remove it, the best materials, and the effectiveness of each kind.

Objective: Our study aims to compare different types of choanal atresia stents and flaps and the outcome of different kinds of stents and flaps that use post-operatively. Also, to assess the risk of restenosis post-operatively with varying types of Stent and flaps.

Methods: A systematic review via databases for different types of stents and flaps used in choanal atresia, including 31 studies with precise technique, variety of stents, restenosis rates, and risk factors (unilaterality, the component of the atretic plate). And about 10 different approaches to flaps reconstruction were mentioned.

Results: According to the data, we observed a successful rate of choanal atresia repair by using the ordinary ETT post-operatively ranged from 28 to 94.2%, which could be explained due to many factors. Post-operative Instructions on care and suctioning provided a good impact. Other types of stents found in case series like steroid eluting stents, Nelaton catheters, Silastic stents, or modified ETT have a promising future during 26 to 39 weeks follow-up. Still, they need further studies with randomization and more data. Flaps with different approaches and techniques showed promising results and fewer complication rates with or without stents, also now have been used in practice providing suitable alternatives for stents.

Conclusion: The original types of choanal atresia stents were shown to have a wide variety of results, while innovative materials of stents showed promising results, however, in relatively small case studies. Flaps were now used in practice giving other choices for stents with fewer complications, better healing, and new choana formation.

Keywords

choanal atresia, choanoplasty, flaps, stents, repair

Introduction

Choanal atresia is a congenital disease caused by obliterating the posterior choanae in the nasal cavity by an atretic plate that separates the nasal cavity from the nasopharynx.^{1,2} The atretic plate is believed to be caused in utero due to buccopharyngeal membrane persistence. Failure of the bucconasal membrane causes it to rupture, leading to a medial outgrowth of vertical and horizontal processes of the palatine bone with adhesion formation.³ In embryological theory, a misdirection of neural crest cell migration, the obstruction can be either bony or membranous unilateral or bilateral.⁴ Most cases are unilateral.⁵ Roderer first described Choanal atresia in 1755, then better identified by Otto in 1830, and Emmert first treated it surgically in 1853.⁶

The clinical presentation can range from acute airway obstruction to chronic recurrent sinusitis.⁷ It's a medical

emergency if bilateral⁸ Early interventions in neonates are necessary for survival. The unilateral type can be unrecognized for years, and adult bilateral choanal atresia is rare.^{1,9}

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There are many surgical approaches.⁹ To date, no gold standard has been established. Highly advanced transnasal endoscopic approaches are preferred to decrease traumatic injury that leads to postoperative scarring and restenosis.²

Using stents during repair is still controversial.² Stenting is known to minimize the risk of restenosis, but it can lead to infection, scars (especially to septal, alar cartilages, and columella), and granulation formation with the possibility of restenosis.^{2,5} This leads to stents in children with a higher risk of failure, including neonates and bilateral choanal atresia cases. A new reinforced choanal atresia stent patent was granted from the UK (Patent No. GB 2 386 839) and Saudi Arabia (Patent No. 1684 at Saudi Authority for Intellectual Property). A leading choanal atresia stent manufacturer is currently assessing the proto-type for possible commercial production. When available in different sizes, it could be the standard stent for preventing restenosis following the repair of choanal atresia.¹⁰ The aim of our study begins with the comparison of the different types of choanal atresia stents and flaps. Then, the outcomes of utilizing various kinds of stents and flaps post-operatively will be delivered. Finally, a risk assessment will be provided for post-operative restenosis with different types of Stent and flaps.

Methods

This is a systematic review based on data collected from previous studies to compare the outcomes of using different types of stents and flaps until 25 August 2021. The records were identified through a database search for Choanal Atresia Stents and Flaps: PubMed (192), ProQuest (784), Cochrane (26), OVID (659), and Embase (821) for a total of 915 studies found in the primary literature. About 31 studies were included in this study (Figure 1). We highlight the types of stents and techniques used in choanal atresia repair (Table 1), and the component of atresia was a unilateral, bilateral, bony, or membranous atretic plate (Table 2). Each type of Stent is associated with the rate of restenosis, success rate per study, and follow-up period and duration of stents (Table 3). As well as different types of flaps techniques have been mentioned and described whether with or without stents.

Inclusion criteria: It encompasses all previous studies from Pubmed, ProQuest, Cochrane, OVID, and Embase to compare the type of stents and flaps used in choanal atresia until 25 August 2021. Also, included all relevant studies in English.

Exclusion criteria: This includes incomplete data, missing data, no relevance to the study, and not original research.

Limitations

Several studies did not record how many patients were studied, such as case reports and experimental, restenosis rate not mentioned, or short follow-up period.

Results

This is the first review article that addresses different types of stents and flaps used for choanal atresia repair to the best of our knowledge. We found that the total number of cases that used Stent postoperative, included in this review, is 557 cases, age recorded from the neonatal period up to 28 years-old. Stated data showed 145 male patients while females are 245, Mixed atresia 178, Bony atresia 158, Membranous atresia 7 cases.

According to the data, we observed a successful rate of choanal atresia repair by using ETT post-operatively ranged from 28 to 94.2%, which could be explained due to many factors playing a role in the success rate such as whether unilateral or bilateral, stent duration, type of ETT and type of atresia, surgical approaches: trans-septal, trans-antral, trans-palatine, and trans-nasal, using flaps in addition to the Stent and using of mitomycin in some studies.

Post-operative Instructions on care and suctioning positively impacted restenosis rates regardless of the type of Stent used. Other types of stents found in reports, like Nelaton catheter, Silastic stent, or modified ETT, have a promising future during a follow-up period up to 26 to 39 weeks but need further studies with randomization and more data.

The best outcomes were 100% successful with Teflon stent, Metal-reinforced silicon ETT, Nelaton in the unilateral case for each, and Silicone stent, used in 2 cases of bilateral choanal atresia for two weeks. The same percentage with stenting consists of steroid eluting stents up to 16 years old. Meanwhile, steroid eluting stents were shown to have a 100% success rate in 2 out of three studies done using steroid eluting stents, followed by 94.2% successful by ETT in 52 neonates with bilateral choanal atresia in which Fearon dilators were used then rubber catheters initially.

Silastic stent showed 93.3% success in 15 cases up to 15 years in bilateral and unilateral cases.

The most unsatisfactory outcomes are 14.28% successful with using Reinforced ETT (Silicone) in 7 bilateral and unilateral. All patients with bilateral choanal atresia had a history of stent removal with subsequent dilatation. But at six months, all choana were patent, followed by 25% in ETT when used in 4 neonates with bilateral choanal atresia. Then 28.5% for Polyvinyl chloride ETT when Mitomycin C was used in some cases, and the same percentage with Silicone in 49 cases up to 13 years old.

In studies that mentioned using Stent exclusively in cases with bilateral choanal atresia, Sarfan and De Freitas used Modified ETT showed successful rates of 40% and 70%, respectively. On the other hand, Portex ETT successful rate ranged between 50.6 to 92.5% in four studies, ETT stent in bilateral atresia used by Zuckerman, Sadek and Gujrathi CS number of patients 4,8, 52 respectively, with successful rate ranged between 25 to 94.2% with an apparent increase in successful respectively with increasing sample size.

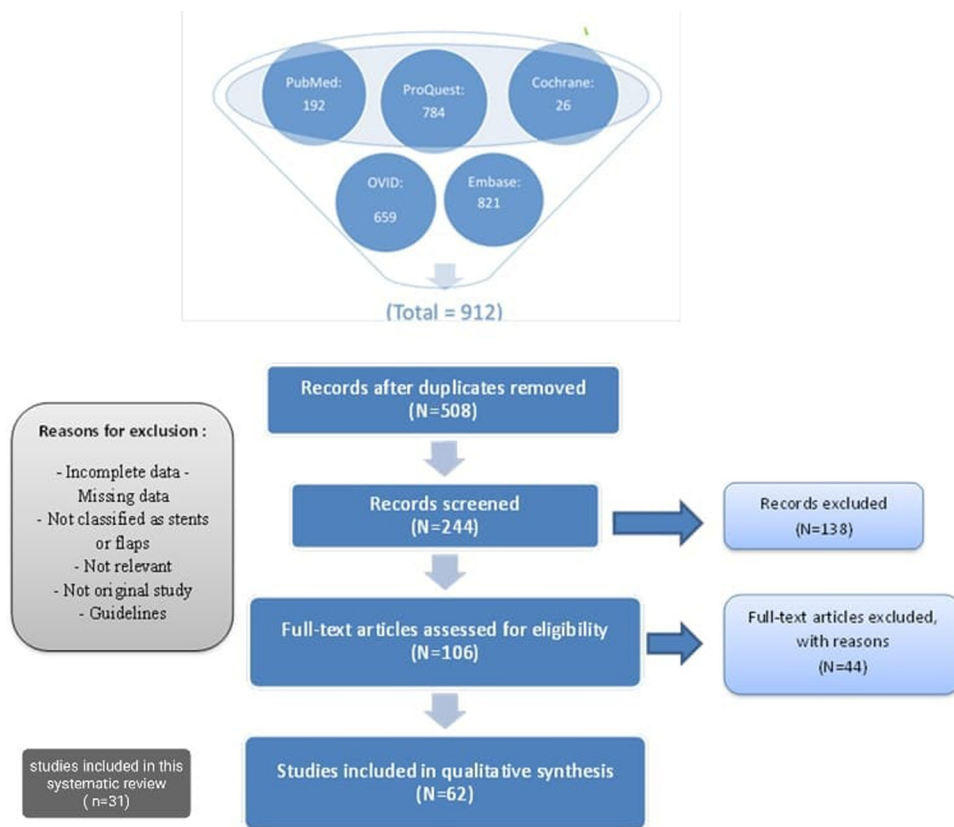


Figure 1. Modified and attached.

Silastic, fashioned from portex ETT also used in 37 cases of bilateral choanal atresia, showed 70.2% success.

Flaps with different approaches and techniques showed promising results and fewer complication rates with or without stents, also now have been used in practice providing suitable alternatives for stents.

Discussion

Many kinds of stents are used to keep the choana patent to heal mucosa and subsided atretic plates. Several studies have compared choanoplasty with and without stents; our study aims to compare the outcomes of different stent types. Stents were proven to be suitable in bilateral cases.¹¹⁻¹³

There is no fixed stent type, and most stents have to be customized and measured at the time of surgery. However, the most common type is the standard endotracheal tube (ETT).¹⁴ Some better results were shown with the transnasal approach in unilateral cases without stents due to the less traumatic and easier post-operative care.¹⁵

Some used an endoscopic approach using a micro-debrider in unilateral choanal atresia in seven patients, and topical mitomycin was applied without stenting; 85.7% of them had patent choanae.¹⁶

In more advanced techniques such as the KTP laser, Tzifa and Skinner described the endoscopic endonasal repair in unilateral choanal atresia using KTP laser without using stents with 100% success no dilatation or debridement was needed.¹⁷

Flap techniques can prevent restenosis. Restenosis is commonly seen in bilateral choanal atresia with bony atretic plate, with associated malformations.¹⁸

The success of surgical outcomes is predisposed by laryngopharyngeal reflux, GERD, age younger than ten days, bilateral choanal atresia with purely bony atresia, and associated malformations and syndromes.^{7,19}

The use of stents carries risks, including injury to the nasal mucosa by pressure, scarring, granulation tissue formation, bacterial overgrowth, contamination as a foreign body, and blocking of mucociliary drainage.^{9,19,20} Soft material can be an endoprosthesis for a short time to reduce the possibility of granulation tissue formation and postoperative infection, thus reducing the risk of restenosis.²¹ Some suggested a short posterior-based stent that fixed sub-labially.²²

Stents of portex polyvinyl chloride are strongly recommended by many surgeons due to its good outcome with fewer complications using a polyvinyl stent.^{23,24} It is the most common type of Stent. The posterior end of the Stent should go through the posterior choana, yet it should not

Table 1. Types of Post-operative Stents and Patients' Characteristics and Demographics in Different Studies.

Study	Type of stent	No. of patients used stent	Age	Gender		Unilateral		Bilateral
				M	F	Rt	Lt	
1	Newman 2013 ¹⁷	31 pt 36 sides	3d-15 y	NS	NS	NS	NS	NS
2	Van Den Abbeele 2002 ²⁶	40	3d-15 y	16	24	18	8	14
3	Saafan 2013 ¹⁸	10	NS	NS	NS	0	0	10
4	Eladl 2010 ⁴³	7	3-27 d	3	4	0	0	7
5	Al-Ammar 2007 ⁴⁸	5	NS	1	4	0	0	5
6	Zuckerman 2008 ⁵⁰	4	6-16d	2	2	0	0	4
7	Kinis 2014 ⁵¹	26 ●	3-110d	9	24	0	13	20
8	De Freitas 2012 ⁵²	20 ●●	0-32 d	5	18	0	0	23
9	Uzomefuna 2012 ⁴⁹	14 ●●●	1-12 w	4	10	1	1	12
10	Romeh 2010 ⁵³	54	7d-14 y	21	33	23	9	22
11	Nour 2008 ⁴⁰	14	2-25 d	4	10	0	0	14
12	Khafagy 2002 ⁵⁴	9	2-21 d	2	7	0	0	9
13	Eladl 2016 ⁵⁵	83	1-28d	NS	NS	0	0	83
14	Yaniv 2007 ⁴² "flap"	17	2m -13y	8	9	3	8	6
15	Sadek 2000 ²⁵	8	2-39 d	4	4	0	0	8
16	Pasquini 2003 ⁴⁴ "flap"	3	5d - 15 d	2	1	0	9	3
17	Kim 2012 ¹⁹	9		2	7			
18	Gujrathi 2004 ⁵⁶	14 pt 21 sides	6d - 28 y	NS	NS	NS	NS	NS
19	Wiatrak 1998 ⁵⁷	52	8-14d	21	31	0	0	52
20	Deutsch 1994 ⁵⁸	13	3- 109m	7	6	9	4	0
21	Sharma 2006 ⁵⁹	2	3-7 d	1	1	0	0	2
22	Rodriguez 2014 ²⁸	7	NS	4	3	1	0	6
23	Richardson 1988 ³⁰ "flap"	49	3 d- 13 y	19	30	11	5	33
24	Josephson 1998 ³¹	37	0-8 y	NS	NS	0	0	37
25	Mantovani 2009 ⁶ "flap"	15	2d -15 y	5	10	10	0	4
26	Al-Qahtani 2003 ³²	1	4 d	1	0	0	0	1
27	Ceylan 2007 ³⁴	1	2 y	1	0	0	0	1
28	Bangiyev JN 2017 ³⁵	3	7 d	0	1	0	0	1
29	Wilcox LJ 2020 ³⁶	5	4d-16y	1	2	1	1	2
30	Meleca JB 2019 ³⁷	3	0.33-92m	2	3	2	1	2
31	Wang P 2021 ⁶⁰ "flap"	22	8d-38m	2	1	2	0	1
		15	5d-36 m	8	14	8	7	14
				6	9	7	8	8

M: Male, F: Female, Rt: Right side, Lt: Left side, Pt = Patient

NS = Not stated, mainly due to not reported separately for stented versus non-stented patients or due to insufficient data.

● Actual number of pt is 33, 7 pt excluded from the study. (1 patient had bleeding during OR leads to death post-operatively).

●● Actual number of pt is 23, 3 pt excluded from the study.

●●● Some pt in this study has unspecified atresia type.

Table 2. Component of the atresia.

Study	Type of stent	Mixed atresia	Bony atresia	Membranous atresia
1 Newman 2013 ¹⁷	Modified ETT	NS	NS	NS
2 Van Den Abbeele 2002 ²⁶	Portex ETT	21	19	0
3 Saafan 2013 ¹⁸	Modified ETT	NS	NS	NS
4 Eladl 2010 ⁴³	Portex ETT	3	4	0
5 Al-Ammar 2007 ⁴⁸	Polyvinyl chloride ETT	1	2	NS
6 Zuckerman 2008 ⁵⁰	ETT	NS	NS	NS
7 Kinis 2014 ⁵¹	ETT	22	11	NS
8 De Freitas 2012 ⁵²	Modified ETT	0	20	0
9 Uzomefuna 2012 ⁴⁹	Polyvinyl chloride ETT	4	NS	2
10 Romeh 2010 ⁵³	Portex ETT	33	21	0
11 Nour 2008 ⁴⁰	Portex ETT	12	2	0
12 Khafagy 2002 ⁵⁴	Portex ETT	6	3	0
13 Eladl 2016 ⁵⁵	Portex ETT	NS	NS	NS
14 Yaniv 2007 ⁴² “flap”	Portex ETT	0	17	0
15 Sadek 2000 ²⁵	ETT	0	8	0
16 Pasquini 2003 ⁴⁴ “flap”	ETT	NS	NS	NS
	Silastic			
17 Kim 2012 ¹⁹	Silastic, portex ETT	NS	NS	0
18 Gujrathi 2004 ⁵⁶	ETT	NS	NS	NS
19 Wiatrak 1998 ⁵⁷	Modified ETT	7	6	0
20 Deutsch 1994 ⁵⁸	Silicone	NS	NS	1
21 Sharma 2006 ⁵⁹	Reinforce ETT (Silicone)	3	3	1
22 Rodríguez 2014 ²⁸	Silicone	43	6	0
23 Richardson 1988 ³⁰ “flap”	Silastic, fashioned from portex ETT	14	23	0
24 Josephson 1998 ³¹	Silastic	6	8	1
25 Mantovani 2009 ⁶ “flap”	Teflon stent	0	1	0
26 Al-Qahtani 2003 ³²	Metal-reinforced silicone ETT	NS	NS	NS
27 Ceylan 2007 ³⁴	Nelaton catheter	0	1	0
28 Bangiyev JN 2017 ³⁵	Steroid eluting stents	1	1	1
29 Wilcox LJ 2020 ³⁶	Steroid eluting stents	2	2	1
30 Meleca JB 2019 ³⁷	Steroid eluting stents	NS	NS	NS
31 Wang P 2021 ⁶⁰ “flap”	Silicone	21	1	0
	Steroid eluting stents	15	0	0

NS = Not stated, mainly due to not reported separately for stented versus non-stented patients or due to insufficient data.

contact the nasopharyngeal wall. The length should be satisfactory to help the newly shaped choana yet be adequately shaped not too long to cause trauma and avoid regurgitation of the food. It is customized to cover up around 3 to 4 mm behind the alar edge. The Stent should not distend from the nose to prevent it from removal by the child and avoid psychological and social effects in older children of its appearance.²⁵

Newman used a 3.5-mm uncuffed endotracheal tube with some modifications (bending the tube in half-length-wise and cutting halfway through its diameter) to allow the tube to maintain this bend. In addition, the tube was placed with the cut edge posterior. At the end of this study, they found a lower revision rate when stents were left in place for 15 to 28 days (7% revision rate) versus 1 to 14 days (38% revision rate); postoperative dilation was needed in some cases.¹⁸

The disadvantages of polyvinyl chloride material commonly relent at internal nasal temperature and may fail to stay patent under surrounding pressure leading to restenosis.²⁶

Sadek advocated a new modified stent using an endotracheal tube placed beyond the atretic plate. This may decrease the risk of restenosis. In addition, he claimed that this Stent minimizes restenosis by epithelization of the newly formed choana.²⁶

Van Den Abbeele used polyethylene tracheal tubes; he found no significant difference in the success rate for unilateral versus bilateral atresia repair.²⁷

Placement of a silicone-based stent was an alternative for Rodríguez et al, who had good airway ventilation of more than 90% of the patients who underwent microscopic repair. This team used a silicone stent (Foley probe number 12-18). The time was shorter in unilateral choanal atresia, fixed to the columella, and longer in bony plates. In bilateral atresia, the Stent was placed as a perforated “U” on the posterior part without stitching; topical mitomycin C was used in 14 patients (28.6%). Nine patients (18.4%) presented with complications, and most of them were related to the nasal

6 **Table 3.** Outcomes, including Success, Failure rates, revision procedure, stent duration, and follow-up of the included studies.

Study	Type of Stent	Success	Factor of success	Restenosis	Additional procedure*		Stent Duration	Follow-up
					Revision	Re-dilatation		
1 Newman 2013 ¹⁷	Modified ETT	28/36 sides (77.7%)	Transnasal endoscopic approach, Delaying repair for unilateral atresia	8/36 sides (22.2%)	8	NS	1 - < 28 d	Up to 777 w
2 Van Den Abbeele 2002 ²⁶	Portex ETT	32 (80%)	Transnasal endoscopic approach, Patient age (10 days), Surgeon experience	8 (20)	6	-	1-2 d	mean 78 w
3 Saafan 2013 ¹⁸	Modified ETT	4 (40%)	Type of stenting	6 ** (60%)	NS	NS	4 w	52-260 w
4 Eladl 2010 ⁴³	Portex ETT	5 (71.4%)	Transnasal endoscopic approach, Powered instrumentation, Stenting	2 (28.5%)	0	2 ***	1-4 w	34-152 m
5 Al-Ammar 2007 ⁴⁸	Polyvinyl chloride ETT	3 (60%)	Stenting in bilateral atresia, Patient age for unilateral atresia (older than 1 year)	2 (40%)	NS	NS	4-6 w	52-313 w
6 Zuckerman 2008 ⁵⁰	ETT	1 (25%)	Transnasal endoscopic approach, Single-stage procedure, Avoidance of stenting, Age of the patient	3 (75%)	3	3	4-6 w	8-56 w
7 Kinis 2014 ⁵¹	ETT	16 (61.5%)	Transnasal endoscopic approach, Age of the patient	10 (38.4%)	NS	NS	3-21 d	26-265 w
8 De Freitas 2012 ⁵²	Modified ETT	14 (70%)	Transnasal endoscopic approach, Duration of stenting (3 months)	6 (30%)	6	-	5-158 d	28-338 m
9 Uzomefuna 2012 ⁴⁹	Polyvinyl chloride ETT	4 (28.5%)	Transnasal endoscopic approach, Age of the patient, Type of stenting	10 (71.4%)	10	-	4-14 w	4 - 156w
10 Romeh 2010 ⁵³	Portex ETT	50 (92.5%)	Frequent follow-up, Surgeon experience Short duration of stent	4 (7.4%)	4	12	5-7 d	52 - 243 w
11 Nour 2008 ⁴⁰	Portex ETT	13 * (92.8%)	Type of flap	0 (0%)	0	0	3-4 w	17-156 w
12 Khafagy 2002 ⁵⁴	Portex ETT	6 * * (66.6%)	Transnasal endoscopic approach	2 (22.2%)	2	0	5-8 w	52-78 w
13 Eladl 2016 ⁵⁵	Portex ETT	42 (50.6%)	Transnasal endoscopic approach, Mucosal resurfacing of single wide neo choana, Frequent follow-up	41 (49.3%)	NS	62 * * *	2-6 w	NS
14 Yaniv 2007 ⁴²	Portex ETT	15 ◇ (88.2%)	Transnasal endoscopic approach, Flap rotation	2 (11.7%)	NS	NS	6 w	10 -60 w
15 Sadek 2000 ²⁵	ETT	7 (87.5%)	Transnasal endoscopic approach, Fixation of stent	1 (12.5%)	NS	1	26-34 w	78 - 573 w
16 Pasquini 2003 ⁴⁴	ETT	11 (91.6%)	Mucosal resurfacing of neo choana, Transnasal endoscopic approach, Soft stent material	1 (8.3%)	1	3	3-7 d	8-278 w
17 Kim 2012 ¹⁹	Silastic, Portex ETT	12 /21 sides (57.1%)	Type of stent	9 /21 sides (42.8%)	9	9	1-2 w	NS
18 Gujrathi 2004 ⁵⁶	ETT	49 (94.2%)	Puncture, dilatation, and stenting	3 (5.7%)	2 ◇◇◇	3 ◇◇◇	Mean 12.2 w	Mean 125 w
19 Wiatrak 1998 ⁵⁷	Modified ETT	10 (76.9%)	Transnasal endoscopic approach, Duration of stenting (6 weeks)	3 (23%)	1	3	6 w	13 - 365 w

(continued)

Table 3. Continued.

Study	Type of Stent	Success	Factor of success	Restenosis	Additional procedure*			Stent Duration	Follow-up
					Revision	Re-dilatation	Stent		
20 Deutsch 1994 ⁵⁸	Silicone	2 (100%)	Transnasal endoscopic approach	0 (0%)	0	0	10 d - 2 w	25 w	
21 Sharma 2006 ⁵⁹	Reinforced ETT (Silicone)	1 (14.28%)	Type of stent (Reinforced stent material)	6 (85.71)	NS	6	2-4 w	< 26 w	
22 Rodriguez 2014 ²⁸	Silicone	14 ■ (28.5%)	Transnasal microsurgical repair; Frequent postoperative nasal wash	35 (71.4%)	0	0	1-12 w	52-417 w	
23 Richardson 1988 ³⁰ "flap"	Silastic, fashioned from Portex ETT	26 (70.2%)	Type of stent	11 (29.7%)	NS	NS	4-16 w	NS	
24 Josephson 1998 ³¹	Silastic	14 ■■ (93.3%)	Transnasal endoscopic approach	1 (6.6%)	1	1	3-12 w	26 - 365 w	
25 Mantovani 2009 ⁶ "flap"	Teflon stent	1 (100%)	Stent shape	0 (0%)	0	0	8 w	NS	
26 Al-Qahtani 2003 ³²	Metal-reinforced Silicone ETT	1 (100%)	Type of stent (Reinforced endotracheal stent)	0 (0%)	0	0	6 w	39 w	
27 Ceylan 2007 ³⁴	Nelaton	1 (100%)	Type of stent	0 (0%)	0	0	8 w	26 w	
28 Bangiyev JN 2017 ³⁵	Steroid eluting stents	3 (100%)	Type of stent with steroid	0 (0%)	0	0	NS	39-52w	
29 Wilcox LJ 2020 ³⁶	Steroid eluting stents	5 ■■■ (100%)	Type of stent (Steroid eluting stent)	0 (0%)	0	0	NS	Mean 2-17.7w	
30 Meleca JB 2019 ³⁷	Steroid eluting stents	2 (66.6%)	Type of stent (Steroid eluting stent)	1 ■■■■ (33.3%)	0	0	NS	26-73.8w	
31 Wang P 2021 ⁶⁰ "flap"	Silicone Steroid eluting stents	20 (90.9%) 15 (100%)	Flap technique Type of stent (Steroid eluting stent)	2 (9.1%) 0 (0%)	2 0	0 0	4w 4w■■■■■	91-156w 43-91w	

Pt = patient.

Re-dilatation includes: debridement, granulation tissue removal and re-dilatation.

* Additional procedure includes: revision, re-dilatation, debridement.

** Stenosis: 4, closure: 2, granulation: 5.

*** 2 cases required minor debridement.

★ The remaining 1 pt died 3 m post-operatively, due to unrelated cause to the surgery.

★★ 1/6 died due to unrelated cause. 1 failure (died shortly post-operatively), 2 revision.

★★★ Number of cases needed second look surgery.

◇ 2 of them had mid-nasal synechiae.

◇◇ During F/U period, 2 pt required transeptal repair. 3 pt required immediate re-stenting after stent removal.

◇◇◇ All pt with bilateral choanal atresia, had hx of stent removal with subsequent dilatation, but at 6 months all choana were patent.

■ 1/49 died 8 year post-operatively, total number of pt with patent choana after revision were 46 pt.

■■ 1/14 died.

■■■ 1 case had granulation tissue formation, treated by drops no surgical intervention was needed.

■■■■ this case developed restenosis and treated by drops no surgical intervention was needed.

■■■■■ steroid stent that used in this study was designed to dissolve over 30 days.

Stent, seven patients (4.1%). They concluded that revisions were more frequent among patients with bilateral, bony plates with associated malformations.²⁸

The advantages of Foley catheter stenting for choanal atresia, as described by Bartal, include better patient tolerance and easier introduction, fixation, and removal. In addition, there can be a lower rate of complications such as septal and columellar necrosis and infections of the nasal cavity and paranasal sinuses. It has been comfortably used in unilateral atresia cases with a good satisfaction rate and less restenosis and complications rates.²⁹

Richardson and Osguthorpe used Silastic tubes as stents to 37 patients with bilateral choanal atresia or choanal stenosis post-operatively. They used transnasal and transseptal techniques. The flaps were elevated, preserved, and rotated posteriorly after removing the atretic plate with a drill. The transnasal curette used a curette to perforate the plate. The Stent was held postoperatively for 12 to 16 weeks due to a large amount of mucosa sacrificed. At the end of the study, they found 9 of 25 transnasal patients (36%) had restenosis and required further intervention; 1 of them had bilateral stenosis.³⁰

Josephson used a soft silastic stent with a foam cuff post-operative in 15 patients, fixed anteriorly by nylon suture. Patient ages ranged between 2 days-15 years.³¹

A new customized dynamic endonasal Teflon stent nicknamed “little gun” was used after elevating a fibro-mucosal flap in a 4-day-old male. The Stent made of .25-mm-thick Teflon—a biocompatible material that does not seem to affect the mucociliary clearance is completely intranasal and better tolerated and individually customized. A cautious estimate of its length is important. Daily saline irrigation was required with a twice-monthly examination. Two months after the operation, the Stent was removed and replaced with a new stent with a different size.⁶

Al-Qahtani used a stent with a coiled metal embedded in the stent wall for a case of choanal atresia. A metal-reinforced silicone rubber tracheal tube (3.5 internal diameters;

Sims-Portex, UK) was trimmed and shaped and was cut elliptically from the middle creating two separate sections connected posteriorly to become U-shape.¹⁰

Al-Qahtani found that their approach is superior because the metallic implant stands the pressure of the tissues around the tube, minimizing the probability of restenosis. The tube was Z79-IT, approved to be harmless to the mucosa with minimal granulation tissue and scar formation. The Stent was made of reinforced silicone rubber, which showed a shorter operative time. This metal wire also has flexibility and is easily introduced into the nose. A sponge is attached to the Stent at the columellar angle to prevent pressure necrosis, a common complication in the columella.³²

A tracheostomy tube was made of silastic material as a stent, as described by Sculerati. It was cosmetically acceptable. Although local infections were encountered, these could be avoided by nasal irrigation and oral antibiotics.³³

The placement of the Nelaton catheter was described by Ceylan as an alternative, primarily due to availability and cost. This was size 14 with an outer diameter of 4 mm, and nylon sutures secured them into the nasal vestibules.³⁴

A novel stenting method consists of steroid eluting stents to prevent restenosis in three studies; Bangiyev et al reported the use in 3 patients ranging from newborn to 16 years. After 9- to 12-months follow-up post-operative, all patients did not require any additional CA revisions, although one patient underwent endoscopic removal of the Stent after two weeks from operation.³⁵ Mometasone drug-eluting stents were used in five cases the age up to 90 months old, two bilateral and three unilateral CA. Post-operative one patient had granulation tissue, but no restenosis was reported among them during the follow-up period.³⁶

Meleca et al had two unilateral and one bilateral choanal atresia patients, with ages ranging from 8 days-38 months old, with follow-up 6 to 17 months. Although all choana were patent, only one patient showed restenosis, which is treated non-surgical and improved.³⁷

Many shapes of mucosal incisions are described throughout many studies. For example, the “nasal septal crossover flap technique” was performed through a

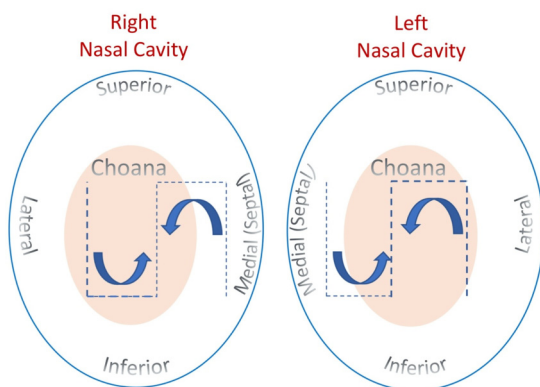


Figure 2. Drawing illustration of the nasal septal crossover flap technique of both choanae.

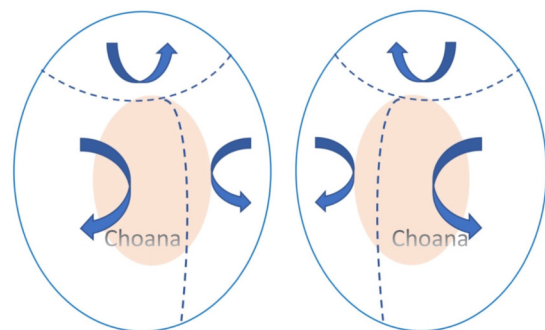


Figure 3. Drawing illustration of the T-shaped incision with mucosal flaps of both choanae.

successful and restenosis rate



Figure 4. Success rate and restenosis rate chart, in studies which used stent post-operative.

transnasal micro-endoscopic approach in about 33 patients. The idea from this flap is to create an L-shaped incision separating the mucosa into superior and inferior mucosal flaps (Figure 2). Their success rate was 86% for unilateral cases and 72% for bilateral cases.³⁸

Some flaps are described as a laterally based “C”-shaped incision. This is done infero-medially, extending laterally parallel to the nose floor via a CO₂ laser to excise the

atretic plate and customize a medially based mucosa flap toward the septum in unilateral cases.³⁹

Nour and Foad mentioned a new technique called swinging door. First, the flaps were elevated to create a lateral trapezoid-fashioned septal mucosal flap on both sides of the posterior choana using a radiofrequency needle. Next, flaps were fashioned and applied to cover the exposed lateral bony choana. Finally, the newly created choana was

sized as if it could accommodate a 4 mm Portex endotracheal tube in each choana comfortably.⁴⁰

A single side-hinged flap was illustrated by Saraniti, who mentioned a vertical incision was placed in the mucosa with a sickle knife at the atretic plate junction via a vomer bone. There were two horizontal incisions: One higher at the choana superiorly and another lower at the junction between the atretic plate and the floor of the nasal cavity. A flap with a side-hinged is elevated and displaced laterally. Of 18 cases presented in the study, only two patients (11.11%) showed partial restenosis; one was bilateral choanal atresia.⁹

Similarly, Ibrahim et al performed a single side mucoperiosteal flap with an endoscopic procedure without stents to treat 21 children. A curved "C"-shaped incision made approximately .5 cm anterior to the suspected area of the atretic plate. The incision was around 7 mm in length over the posterior part of the septum, overlying the vomer with its base toward the lateral wall of the choana. The laterally elevated mucoperiosteal flaps were. The restenosis rate was 14% (3 out of 21), and all were bilateral cases.⁴¹ This type of flaps was also described by Yaniv et al A mucosal perichondrial periosteal flap and portex ETT were used as a stent post-operative in 17 cases; restenosis occurred in 2 cases.⁴²

A T-shaped incision of the mucosa was made using a pointed cautery tip with the vertical limb of the letter T more towards the nasal septum. Flaps were raised superiorly, laterally, with a small flap medially. It covers the inferior surface of the sphenoid plate and the exposed medial wall of the pterygoid plate. The medial flap covered the posterior exposed part of the bony septum that was shorter to interlace with the medial flap of the other side of the choana (Figure 3). There was a reasonable success rate with no restenosis after endoscopic transnasal repair with drilling by micro-debrider of bilateral choanal atresia in an adult, as reported by Gawai & Shah.⁴³

Incision between vomer and cartilage was done, followed by creating anterior and posterior mucoperiosteal flap mentioned in Pasquini et al study. Both ETT and silastic stents were used as stents post-operative.⁴⁴

Cedin *et al* demonstrated a folded-over-flap technique without the need for using stents of any type in 10 patients with postoperative normal airway patency, without restenosis or revision surgery.⁴⁵

An Egyptian study that compared the repair of the L-shaped septo-nasal flap stentless against the flapless stented technique (using size 3.5 Portex® endotracheal tube) for bilateral choanal atresia repair using laterally based septonasal flaps. The flap is done by creating an incision vertically at the bony-cartilaginous junction with the mucoperiosteal flap 1 cm anterior to the atretic plate. They included 72 patients under their randomized controlled trial, 42 were using the flap without a stent. 13 failed cases had revision surgery to remove granulation

tissue and open adhesions, achieving patency in 10 out of 13 patients. Restenosis found in 9 out of 42 patients used flap without stents, and in 10 out of 30 patients stented without flaps.⁴⁶

Another simple flap is done by incision of the mucosa at the level of the bony-cartilaginous junction between the vomer and septal cartilage to elevate anterior and posterior mucoperiosteal flaps, with a success rate of 92.8%.⁴⁷ Similarly, a more posterior vertical incision made over the atretic plate representing an I-shaped incision with a rotation of the flaps laterally, this technique showed unilateral restenosis in 8 out of a total of 25 patients, and one patient had a bilateral restenosis.⁴⁸

A summary of the success and restenosis rates of the included studies which used stents postoperative in our review is simply highlighted (Figure 4).

One of the factors which can affect the success and restenosis rate is using mitomycin, and some studies mention that, such as Newman, Kim, and Uzomefuna.^{18,20,49}

Some surgeons believe the repair without stenting reduces the potential risks for stent-related complications, such as, localized infection, ulceration and granulation tissue formation. Also other authors recommended removal of the posterior part of the vomer in bilateral choanal atresia endoscopically, in 7 and 25 patients, respectively, aged less than 15 days. Their study found that resecting of the posterior part of the vomer first before removing going laterally to the atretic plate and to the medial pterygoid plate, which they found doesn't require the use of stents or flaps.^{61,62}

Conclusion

We concluded that patients were less likely to have restenosis or complications if the stents were used appropriately with clear guidance and education to the patient's relatives for the treatment and suction of any secretions, which can help avoid potential complications or restenosis for any stent type. Many stents and novel approaches display promising results and a lower risk of infection, but many have limited follow-up periods and a small number of samples. New techniques showed better results, such as steroid eluting stents, silastic stents, and nelaton catheters. Similarly, flaps were now used in practice giving other choices for stents without the known complications of stents with better healing and better new choana formation. We need further studies with extended follow-up periods and a comprehensive rate and technique of complications to fully comprehend whether one form of a stent is better than the others. We emphasize the importance of pre-operative workup. The use and type of stents should be decided before booking the patient for repair, and every patient should be treated individually.

However, it should be kept in mind that the type of stents or flaps are only a few contributing factors, and other confounding factors should also be considered. Further

prospective randomized studies are required for review and analysis in the future.

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Informed Consent

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Trial Registration

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Supplemental Material

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