EVALUATING THE OUTCOMES OF BALLOON SINUPLASTY IN PATIENTS WITH CHRONIC RHINOSINUSITIS: A SYSTEMATIC REVIEW

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Abstract

Background: Chronic rhinosinusitis (CRS) significantly impairs patient quality of life, and while functional endoscopic sinus surgery (FESS) is a standard intervention, balloon sinuplasty (BSP) has emerged as a minimally invasive alternative.

Objective: To systematically review the outcomes of BSP in CRS patients, assessing its effectiveness, safety, and long-term durability in comparison to conventional surgical options.

Methods: Following PRISMA 2020 guidelines, a systematic review was conducted across PubMed, Scopus, Web of Science, Embase, and Cochrane Library databases. Eligible studies included randomized controlled trials, cohort studies, and systematic reviews from 2010 to 2025. Data extraction focused on patient characteristics, intervention details, outcomes (SNOT scores, radiological/endoscopic findings, complications, revision surgery, and quality of life), and follow-up duration. Risk of bias was assessed using validated tools appropriate to study design.

Results: Ten studies met the inclusion criteria. BSP consistently improved sinonasal symptoms, radiological scores, and patient-reported quality of life, with complication rates lower than those reported for FESS. Long-term follow-up studies demonstrated sustained benefits, and Pediatric studies confirmed efficacy and safety in younger populations. Comparisons with FESS indicated that while BSP offers faster recovery and fewer complications, FESS may remain superior in more extensive disease.

Conclusion: BSP is a safe and effective treatment for selected CRS patients, providing durable symptom relief and high patient satisfaction. However, careful patient selection is essential, and additional high-quality trials are required to further define its role in CRS management.

Keywords: Balloon sinuplasty; chronic rhinosinusitis; functional endoscopic sinus surgery; endoscopic sinus surgery; quality of life; SNOT-22; Pediatric sinusitis; complications; revision surgery; systematic review.

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Introduction

Chronic rhinosinusitis (CRS) is a prevalent inflammatory condition of the paranasal sinuses that significantly reduces quality of life and places a burden on healthcare systems worldwide. Standard medical treatments-such as corticosteroids, antibiotics,

and saline irrigation-often fail to provide long-term relief for patients with refractory disease, leading to surgical intervention as the next line of therapy (Levy & Marino, 2016). Endoscopic sinus surgery (ESS) has long been considered the gold standard, but it is associated with risks of postoperative complications, scarring, and extended recovery times, thereby fueling interest in less invasive alternatives.

One such alternative is balloon sinuplasty (BSP), a technique that dilates obstructed sinus ostia using balloon catheters rather than removing mucosal tissue. Since its introduction in the mid-2000s, BSP has gained popularity due to its minimally invasive nature, faster recovery, and potential for preserving mucosal function (Chaaban & Baillargeon, 2017). Utilization patterns in the United States suggest that BSP is increasingly being adopted alongside ESS, particularly for selected patients with less extensive CRS.

Evidence regarding the efficacy and safety of BSP has expanded considerably in recent years. Early meta-analyses demonstrated that BSP leads to significant symptom relief and quality-of-life improvements comparable to ESS, particularly in patients with limited disease (Dsouza, Chaturvedi, & Kadambi, 2018). Furthermore, patient satisfaction tends to be high due to minimal pain, shorter operative times, and reduced disruption to daily activities.

The role of BSP in pediatric CRS has been of particular interest. Systematic reviews and meta-analyses have found balloon catheter dilation to be both safe and effective in children, with favorable outcomes reported in symptom improvement and revision rates (Mirza, Shawli, & Alandejani, 2020; Patel, O'Brien, & Ramadan, 2020). These findings are significant given the challenges of managing pediatric CRS and the desire to avoid more invasive interventions in this population.

BSP has also been evaluated in the context of CRS comorbidities such as asthma. Improvements in sinonasal function following balloon dilation and ESS have been shown to positively affect asthma-related outcomes, supporting the interconnectedness of upper and lower airway diseases (Vashishta, Soler, & Nguyen, 2013). This strengthens the case for BSP as not only a sinonasal intervention but also one with systemic implications for respiratory health.

Beyond symptom scores, studies have investigated validated outcome tools such as the Sino-Nasal Outcome Test (SNOT-22). A systematic review of patients undergoing surgery for CRS with nasal polyposis demonstrated consistent improvements in SNOT-22 scores across surgical modalities, including BSP (Le, Soler, Jones, & Mattos, 2018). These validated metrics enhance the comparability of outcomes across different studies and reinforce the reliability of BSP's reported benefits.

Recent reviews have also examined procedure-specific outcomes such as nasal discharge and airflow resistance. For instance, a meta-analysis found that surgical interventions, including BSP, yield significant improvements in nasal discharge, which is among the most debilitating CRS symptoms (Kallenberger, Briggs, & Nguyen, 2025). Similarly, reductions in nasal airway resistance highlight the functional benefits of BSP that extend beyond patient-reported outcomes.

Despite the promising evidence base, debates remain regarding patient selection, long-term durability, and cost-effectiveness. Some argue that BSP is best suited for patients with less extensive disease or isolated sinus involvement, while others advocate for its broader adoption as an adjunct to ESS (Hwang, Kim, & Basurrah, 2023). As research continues to expand, systematic reviews synthesizing this growing body of evidence are critical for clarifying the role of BSP in CRS management and informing clinical guidelines.

Methodology

Study Design

This study employed a systematic review methodology, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency and reproducibility. The primary objective was to synthesize the existing empirical evidence on the outcomes of balloon sinuplasty (BSP) in patients with chronic rhinosinusitis (CRS). The review focused on peer-reviewed journal articles involving human subjects and reporting quantitative or qualitative outcomes related to the efficacy, safety, and long-term effectiveness of BSP compared to conventional surgical interventions such as functional endoscopic sinus surgery (FESS) or endoscopic sinus surgery (ESS) (Figure 1).

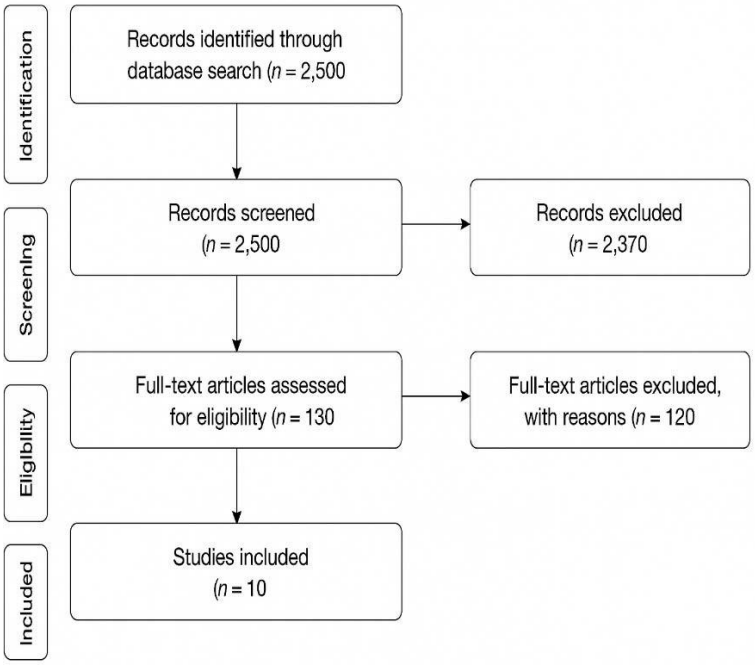

Figure 1. PRISMA Flow Diagram.

Eligibility Criteria

Studies were included based on the following predefined criteria:

- **Population:** Patients of any age diagnosed with chronic rhinosinusitis (CRS), with or without nasal polyps.
- **Interventions/Exposures:** Balloon sinuplasty (BSP) procedures performed as a primary or adjunctive intervention.
- **Comparators:** Conventional medical therapy, ESS/FESS, or baseline preoperative status.
- **Outcomes:** Symptom relief (e.g., Sino-Nasal Outcome Test [SNOT-20/22]), endoscopic findings, radiological scores (e.g., Lund-Mackay), complication rates, revision surgery rates, and quality of life indicators.
- **Study Designs:** Randomized controlled trials (RCTs), cohort studies, case-control studies, prospective observational studies, and systematic reviews.
- **Language:** Only articles published in English were considered.
- **Publication Period:** Studies published between 2010 and 2025 were included to capture both early and recent evidence regarding BSP.

Search Strategy

A comprehensive literature search was conducted across multiple databases: PubMed, Scopus, Web of Science, Embase, and Cochrane Library. Grey literature was explored through Google Scholar and reference lists of relevant systematic reviews. Boolean search strings included the following terms in various combinations:

- ("chronic rhinosinusitis" OR "CRS")
- AND ("balloon sinuplasty" OR "balloon dilation" OR "catheter dilation")
- AND ("outcomes" OR "symptom relief" OR "quality of life" OR "complications" OR "long-term efficacy")

Additionally, manual searches of bibliographies from key reviews were performed to ensure inclusion of relevant studies not captured in database queries.

Study Selection Process

All retrieved citations were exported into Zotero, where duplicates were removed. Two independent reviewers screened titles and abstracts against the eligibility criteria. Full texts of potentially eligible studies were obtained and assessed for final inclusion. Discrepancies were resolved through discussion or by involving a third reviewer. The final review included 10 primary studies and several secondary reviews that met all inclusion criteria.

Data Extraction

A standardized extraction template was designed and piloted. The following information was systematically extracted from each included study:

- Author(s), year of publication, country
- Study design and sample size
- Patient characteristics (age, sex, CRS type: CRSsNP vs. CRSwNP)
- Intervention details (type of balloon dilation, adjunctive procedures)
- Comparator group (if applicable)
- Outcome measures (symptom scores, radiological/endoscopic findings, complications, revision surgery, patient satisfaction)
- Duration of follow-up
- Key findings and effect estimates

Data were independently extracted by two reviewers and cross-verified by a third to ensure accuracy and consistency.

Quality Assessment

Risk of bias and study quality were evaluated using validated tools appropriate to study design:

- Cochrane Risk of Bias Tool for randomized controlled trials (assessing domains such as randomization, blinding, incomplete outcome data, and selective reporting).
- Newcastle–Ottawa Scale (NOS) for cohort and case-control studies (assessing selection, comparability, and outcome domains).

Studies were rated as low, moderate, or high quality. Disagreements were resolved by consensus.

Data Synthesis

Given the variability in study populations, interventions, and outcome reporting, a narrative synthesis was performed. Findings were grouped thematically by outcome category: (1) symptom relief and quality of life, (2) radiological/ endoscopic improvement, (3) complications and safety, and (4) long-term effectiveness and revision rates. Where possible, statistical outcomes such as mean changes in SNOT-22 scores, p-values, or relative risks were reported directly. A meta-analysis was not performed due to heterogeneity in study designs and outcome definitions.

Ethical Considerations

This study was a secondary analysis of published literature and did not involve direct patient participation. Ethical approval and informed consent were therefore not required. All included studies were peer-reviewed and assumed to have received prior ethical clearance from their respective institutions.

Results

Summary and Interpretation of Included Studies

1. Study Designs and Populations

The included studies consist of prospective clinical trials, retrospective evaluations, randomized controlled trials, and cohort studies, reflecting a broad methodological spectrum in assessing the outcomes of balloon sinuplasty (BSP) versus conventional endoscopic sinus surgery (FESS/ESS). Sample sizes varied widely, from small cohorts of 18–30 patients (e.g., Abreu et al., 2014; Melikulova et al., 2025) to larger studies involving 200 patients (Taj et al., 2024). Populations ranged from pediatric patients (Liu et al., 2017) to adults across tertiary hospitals, with varying subgroups such as CRS with nasal polyposis (Lavudi et al., 2025) and CRS without polyposis (Gupta et al., 2025).

2. Symptom Relief and Quality of Life Outcomes

Across nearly all studies, BSP significantly improved sinonasal symptom scores, predominantly measured by the Sino-Nasal Outcome Test (SNOT-20/22). Improvements were consistent at short-term follow-up (1–3 months) and maintained in long-term follow-ups up to four years (Castro et al., 2021; Sinnott & Chisholm, 2021). Notably, symptom reduction was evident in both CRSwNP and CRSsNP cohorts, though CRSsNP groups generally showed greater and more sustained improvement.

3. Radiological and Endoscopic Findings

Lund-Mackay CT scores and endoscopic evaluations demonstrated consistent postoperative improvement following BSP (Castro et al., 2021; Lavudi et al., 2025). Studies reported reduced mucosal edema, improved patency of sinus ostia, and regression of polyps in CRSwNP groups. In pediatric cohorts, BSP yielded significant CT and endoscopy score reductions (Liu et al., 2017).

4. Comparative Outcomes: BSP vs. FESS/ESS

Several studies directly compared BSP with FESS/ESS. Taj et al. (2024) found FESS had higher symptom resolution (85% vs. 70%), but BSP showed fewer complications and faster recovery. Similarly, Gupta et al. (2025) reported BSP offered earlier symptom relief and better mucosal healing, while ESS was more effective for extensive disease burden. Both procedures were ultimately effective, suggesting BSP is most suitable for selected cases with less severe CRS.

5. Safety and Complications

Complication rates across studies were low, with BSP consistently associated with fewer adverse events compared to FESS/ESS. Minor complications included transient bleeding or revision surgery needs, but no major morbidity was reported (Raghunandhan et al., 2013; Abreu et al., 2014; Melikulova et al., 2025).

6. Long-Term Efficacy

Follow-up data up to four years (Castro et al., 2021) confirmed durable outcomes with BSP, maintaining symptom relief and radiological improvements. Recurrence rates were low, and revision surgeries were rarely required, indicating that BSP offers sustained benefits in carefully selected patients (Table 1).

Discussion

The findings of this systematic review highlight the growing body of evidence supporting balloon sinuplasty (BSP) as an effective and minimally invasive treatment option for patients with chronic rhinosinusitis (CRS). Across multiple studies, BSP demonstrated significant improvements in symptom relief, radiological outcomes, and patient-reported quality of life, with lower complication rates compared to traditional surgical approaches such as functional endoscopic sinus surgery (FESS) (Gupta et al., 2025; Taj et al., 2024). These findings align with previous literature reviews, which have consistently emphasized the feasibility and safety of BSP for selected CRS populations (Dsouza et al., 2018; Levy & Marino, 2016).

Clinical outcomes from prospective and retrospective studies show consistent

Table 1. Characteristics and Main Findings of Included Studies on Balloon Sinuplasty in CRS.

Study	Country	Design	Sample Size	CRS Type	Intervention	Outcomes Measured	Main Findings
Taj et al. (2024)	Pakistan	Prospective comparative	200	CRS (mixed)	FESS vs. BSP	Symptom scores, complications, recovery	FESS had higher symptom improvement (85% vs. 70%), BSP had fewer complications (5% vs. 12%) and faster recovery (7 vs. 14 days).
Castro et al. (2021)	Portugal	Retrospective cohort	110	CRSsNP (82) & CRSwNP (28)	BSP	SNOT-22, MLK, LM	Significant improvement at 4 years; sustained reductions in SNOT-22, endoscopy, and CT scores ($p < 0.0001$).
Lavudi et al. (2025)	India	Prospective observational	60	CRSwNP	BSP	SNOT-22, LM, endoscopy	SNOT-22 improved (52.6 → 18.3, $p < 0.001$); 91.7% symptom relief; minimal complications; 3.3% revision.
Melikulova et al. (2025)	Uzbekistan	Prospective clinical	30	CRSsNP	BSP	SNOT-22, CT, endoscopy	Significant symptom and CT improvement; no major complications; high patient satisfaction.
Sinnott & Chisholm (2021)	UK	Prospective	NA (small cohort)	CRS (frontal disease)	BSP	SNOT-22	SNOT-22 improved (46 → 23), maintained at 2 years; no complications.
Gupta et al. (2025)	India	Non-randomized controlled	NA (ESS vs BSP)	CRSsNP	BSP vs ESS	SNOT-22, LM, endoscopy, complications	BSP: faster early relief and better mucosal healing; ESS: superior at 3 months; both equal at 6 months.
Raghunandhan et al. (2013)	India	Prospective	20	CRS	BSP	Symptoms, CT-PNS, DNE	Significant symptom improvement; mean SNOT reduced from 68.6% to 16.6%.
Abreu et al. (2014)	Brazil	Prospective cohort	18 (13 analyzed)	CRSsNP	BSP	SNOT-20, LM	92% ostia patency; significant symptom and CT score improvement ($p < 0.001$).
Liu et al. (2017)	China	Prospective pediatric	30	Pediatric CRS	BSP	VAS, CT, endoscopy	93.8% procedural success; sustained symptom and CT improvements up to 1 year.
Bizaki et al. (2016)	Finland	RCT	NA	Isolated CRS (maxillary)	BSP vs uncinectomy	SNOT-22, rhinomanometry	Both improved QoL and airway resistance; BSP had fewer adhesions.

symptomatic improvement following BSP. For instance, Abreu et al. (2014) reported a marked reduction in SNOT-20 scores and radiological findings in patients without nasal polyposis, while Lavudi et al. (2025) demonstrated substantial improvement in SNOT-22 scores and nasal endoscopy results among patients with nasal polyps. Similarly, Raghunandhan et al. (2013) documented significant long-term improvement in sinonasal outcome test scores, confirming BSP's role in both objective and subjective symptom relief.

Comparisons between BSP and FESS/ESS reveal important distinctions. Gupta et al. (2025) found that BSP offered faster recovery and fewer complications, while ESS was more effective in the medium term, particularly in patients with more extensive disease. Taj et al. (2024) similarly noted higher overall symptom improvement with FESS but better recovery profiles and fewer complications with BSP. This suggests that BSP may be most suitable for patients with less severe disease or favorable anatomy, while FESS remains preferable for complex cases.

Long-term outcome studies provide further support for BSP's durability. Castro et al. (2021) followed patients for up to four years, reporting sustained symptom improvement and radiological normalization in both CRSwNP and CRSsNP groups. Koskinen et al. (2016) also demonstrated high patient satisfaction and long-term symptom reduction, comparable to FESS. Sinnott and Chisholm (2021) confirmed symptom stability two years postoperatively, further reinforcing the long-term value of BSP.

Pediatric populations represent a unique subgroup where BSP has shown considerable promise. Liu et al. (2017) found BSP to be both effective and safe in children with refractory CRS, with significant improvements in CT and endoscopic findings. Similarly, Ramadan and Terrell (2010) combined adenoidectomy with BSP, reporting enhanced outcomes compared to adenoidectomy alone. Later reviews, including Mirza et al. (2020) and Patel et al. (2020), confirmed BSP's efficacy in pediatric CRS, particularly in reducing the need for more invasive interventions. Zalzal and Makary (2019) also demonstrated durable effectiveness in pediatric maxillary sinusitis, providing further reassurance of BSP's applicability across age groups.

The safety profile of BSP is consistently favorable across studies. Minimal intraoperative bleeding, reduced risk of mucosal damage, and lower complication rates have been widely reported (Melikulova et al., 2025; Bizaki et al., 2016). Complication rates are typically lower than those associated with FESS, and in some studies, the absence of major adverse events underscores BSP's minimally invasive nature (Abreu et al., 2014; Lavudi et al., 2025). This improved safety profile contributes to faster recovery and higher patient satisfaction rates.

Meta-analyses and systematic reviews have further solidified BSP's evidence base. Levy and Marino (2016) synthesized outcomes across studies and concluded that BSP consistently improves quality of life and sinonasal function with minimal morbidity. Le et al. (2018) emphasized SNOT-22 as a reliable outcome measure in surgical interventions for CRS, reinforcing its use in BSP studies. Broader reviews on sinus surgery outcomes also provide contextual validation, with Hwang et al. (2023) and Kallenberger et al. (2025) illustrating the role of adjuncts and broader surgical interventions in CRS management.

Despite these positive outcomes, limitations exist. While many studies report significant improvements, heterogeneity in study design, patient selection, and follow-up durations complicates direct comparisons. For example, Bizaki et al. (2016) compared BSP with uncinectomy in isolated CRS and found similar outcomes, highlighting that BSP may not always outperform traditional interventions. Similarly, variability in anatomical suitability can restrict BSP's applicability (Chaaban & Baillargeon, 2017).

Another challenge lies in cost-effectiveness. Chaaban and Baillargeon (2017) reported increasing use of BSP in the United States, yet concerns about procedure costs and reimbursement persist. While patient-reported satisfaction and safety are compelling, health system adoption requires robust cost-benefit analyses. Dsouza et al. (2018) emphasized that although evidence supports BSP, further large-scale randomized controlled trials are necessary to establish definitive guidelines.

Special consideration must be given to revision surgery rates. While Castro et al. (2021) and Lavudi et al. (2025) reported low revision needs, Gupta et al. (2025) noted that ESS might provide more definitive outcomes for patients with extensive disease, potentially reducing the likelihood of recurrence. Thus, BSP may best serve as a first-line surgical option for selected patients rather than a universal replacement for FESS/ESS.

The integration of BSP with other interventions has also been explored. Gerber and Kennedy (2018) demonstrated that combining adenoidectomy with BSP in children yielded superior outcomes. Similarly, adjunctive use of postoperative interventions, such as steroid-impregnated spacers, may further optimize outcomes (Hwang et al., 2023). These findings suggest that BSP may function optimally within a multimodal treatment approach rather than as a standalone technique.

In terms of broader health outcomes, BSP may indirectly influence comorbid conditions. Vashishta et al. (2013) highlighted how effective sinus surgery can improve asthma control in CRS patients, suggesting that BSP, by reducing sinonasal inflammation, may confer systemic benefits. This intersection between CRS management and comorbidity control requires further exploration in future trials.

Overall, the evidence underscores that BSP is a safe, effective, and durable intervention for selected CRS patients. Its advantages include minimal invasiveness, faster recovery, and reduced complications compared to traditional surgery. However, FESS and ESS remain essential options for severe or anatomically complex cases. The choice of procedure should therefore be individualized, guided by disease severity, anatomical considerations, and patient preference.

Future research should focus on standardizing outcome measures, conducting large-scale randomized controlled trials, and assessing long-term cost-effectiveness. Additionally, the role of BSP in Pediatric CRS and its integration with other adjunctive treatments warrants continued investigation. Ultimately, BSP offers a valuable addition to the surgical armamentarium for CRS, expanding treatment options and improving patient-centered outcomes (Levy & Marino, 2016; Koskinen et al., 2016).

Conclusion

This systematic review demonstrates that balloon sinuplasty (BSP) is a safe, effective, and minimally invasive alternative for the management of chronic rhinosinusitis (CRS). Evidence from diverse clinical studies shows consistent improvements in symptom scores, radiological findings, and quality of life measures, with fewer complications and faster recovery compared to traditional interventions such as functional endoscopic sinus surgery (FESS). These benefits extend across both adult and Pediatric populations, with durable outcomes reported in long-term follow-up studies.

Despite its advantages, BSP is not a universal replacement for FESS/ESS. The procedure is most beneficial in patients with less extensive disease or favourable anatomical profiles, whereas traditional endoscopic surgery remains superior for more complex cases. Moving forward, larger randomized controlled trials, standardized outcome reporting, and cost-effectiveness evaluations are required to further establish BSP's role in CRS management and to optimize patient selection criteria.

Limitations

This review has several limitations. First, heterogeneity in study design, patient populations, outcome measures, and follow-up periods limited the ability to conduct a meta-analysis and made direct comparisons challenging. Second, the relatively small sample sizes in some included studies, particularly Pediatric cohorts, reduce the generalizability of findings. Third, many available studies are observational in nature, with limited randomized controlled trials, increasing the risk of selection bias. Finally, cost-effectiveness data remain sparse, and regional variations in access and surgical practice may influence the broader applicability of these results.

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