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Effectiveness of Balloon Sinuplasty Compared to Functional Endoscopic Sinus Surgery in The Management of Chronic Rhinosinusitis

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Abstract
This study addresses the growing clinical interest in minimally invasive surgical approaches for managing chronic rhinosinusitis (CRS), particularly the use of Balloon Sinuplasty (BSP) as an alternative to Functional Endoscopic Sinus Surgery (FESS). While FESS remains the gold standard for severe CRS, BSP has gained attention due to its reduced invasiveness and faster recovery. The purpose of this study is to compare the effectiveness of BSP and FESS in improving clinical outcomes among CRS patients. This research employed a descriptive-analytical literature review approach by analyzing scientific articles from databases such as PubMed, Scopus, and Google Scholar. Selected studies include randomized controlled trials, cohort studies, and meta-analyses that meet established inclusion criteria. Key variables assessed include symptom improvement, quality of life, complication rates, sinus patency, and recovery time. The findings indicate that both BSP and FESS significantly improve symptoms and quality of life, with comparable outcomes in selected patient populations. BSP demonstrates advantages in terms of lower complication rates, reduced intraoperative bleeding, and shorter recovery time, while FESS remains more effective in severe or complex cases involving nasal polyps. In conclusion, both procedures are effective treatment options for CRS, and the choice of intervention should be individualized based on disease severity, anatomical factors, and patient characteristics to achieve optimal clinical outcomes.

INTRODUCTION

In recent years, Balloon Sinuplasty (BSP) has emerged as a minimally invasive alternative to conventional FESS. Unlike FESS, which involves tissue removal, BSP utilizes a catheter-based balloon to dilate the sinus ostium, thereby preserving mucosal integrity and reducing surgical trauma (Fokkens et al., 2020; Hastan et al., 2011; Orlandi et al., 2016). Clinical studies have shown that BSP can provide significant improvements in symptom relief and quality of life, with lower complication rates and faster recovery times compared to traditional surgical techniques. This innovation reflects the growing emphasis on less invasive and patient-centered treatment modalities in modern medicine (Bachert et al., 2018; Hopkins, 2009; Smith et al., 2015).

Despite these advancements, the comparative effectiveness of BSP and FESS remains a subject of ongoing debate in the scientific community. Several studies, including systematic reviews and meta-analyses, have reported that both procedures offer comparable improvements in clinical outcomes, particularly in selected patient populations with mild to moderate disease. However, variations in study design, patient selection, and outcome measures have made it difficult to draw definitive conclusions regarding the superiority of one technique over the other

(Hopkins et al., 2009; Ramakrishnan et al., 2012; Rudmik & Smith, 2011; Stammberger, 1991).

Previous research from databases such as Scopus and Google Scholar indicates that FESS continues to be regarded as the gold standard for patients with severe CRS, especially those with nasal polyps or extensive anatomical abnormalities. Meanwhile, BSP has gained popularity due to its minimally invasive nature and favorable perioperative profile. Comparative cohort studies have demonstrated that both BSP and FESS result in significant symptom improvement and radiological outcomes, supporting their roles as effective surgical options for CRS management.

However, a critical gap in the existing literature lies in the lack of standardized criteria for patient selection and long-term outcome evaluation. Many studies focus on short-term results, while evidence regarding long-term durability, recurrence rates, and cost-effectiveness remains limited and inconsistent. Furthermore, heterogeneity in CRS subtypes, such as CRS with and without nasal polyps, adds complexity to treatment decision-making and highlights the need for more stratified research approaches.

The urgency of this research is further underscored by the increasing trend in the use of BSP as a standalone or adjunctive procedure in clinical practice. Data indicate a significant rise in the adoption of BSP over the past decade, reflecting a shift toward minimally invasive interventions. However, without robust comparative evidence and clear clinical guidelines, the widespread use of BSP may lead to variability in treatment outcomes and clinical decision-making.

This study offers novelty by providing a comprehensive and integrative analysis of BSP and FESS, focusing on multiple outcome parameters including symptom improvement, quality of life, complication rates, and postoperative recovery. Unlike previous studies that often examine a single aspect, this research synthesizes findings across various study designs to present a more holistic understanding of the comparative effectiveness of these two surgical approaches.

The purpose of this research is to critically evaluate and compare the effectiveness of Balloon Sinuplasty and Functional Endoscopic Sinus Surgery in the management of chronic rhinosinusitis. By analyzing evidence from high-quality studies, this research aims to identify the strengths and limitations of each procedure and to determine their appropriate roles in clinical practice based on patient characteristics and disease severity.

The expected contribution of this study lies in providing evidence-based insights that can support clinicians in making informed decisions regarding surgical treatment options for CRS. Additionally, this research seeks to enhance the existing body of knowledge by addressing current gaps and offering recommendations for future investigations. Ultimately, the findings are expected to benefit patients by promoting more personalized, effective, and safe management strategies for chronic rhinosinusitis, while also contributing to the optimization of healthcare resources and clinical outcomes.

METHOD

The research method in this manuscript used a literature review approach that is descriptive-analytical with the aim of comprehensively examining the effectiveness of Balloon Sinuplasty (BSP) compared to Functional Endoscopic Sinus Surgery (FESS) in the management of chronic rhinosinusitis. The data population in this study is all relevant scientific articles related to BSP and FESS, while the data sample is in the form of articles that meet inclusion criteria such as clinical research, cohort studies, randomized controlled trials (RCTs), and meta-analyses published in reputable journals. The sampling technique uses purposive sampling, which is the selection of literature based on the relevance of the topic, the quality of the methodology, and the novelty of the publication. The research instrument was in the form of a data extraction sheet that was used to identify key variables such as symptom improvement, quality of life (SNOT-22), complication rate, ostium success rate, and recovery time. Data validity is carried out through the selection of sources from reputable and peer-reviewed journals, while reliability is strengthened by comparing results between studies to ensure consistency of findings.

The data collection technique is carried out through a systematic search of scientific databases such as Google Scholar, PubMed, and Scopus using relevant keywords, then followed by a screening process based on the title, abstract, and full content of the article. The research procedure starts from problem identification, determination of inclusion and exclusion criteria, literature collection, study quality evaluation, to narrative data synthesis. All data obtained are then classified based on research variables to facilitate comparative analysis between the two methods of medical action.

The data analysis technique used is comparative descriptive analysis, which is by comparing the results of previous research related to the effectiveness of BSP and FESS based on clinical indicators and patient outcomes. The data that has been collected is analyzed qualitatively by emphasizing the patterns of similarities, differences, and trends in results between studies. In addition, a thematic synthesis approach was also carried out to identify the advantages, limitations, and factors that affect the selection of methods of action in chronic rhinosinusitis patients. The results of the analysis are then presented in the form of a systematic scientific narrative to provide a comprehensive picture of the effectiveness of the two procedures as a basis for more appropriate clinical decision-making.

RESULTS AND DISCUSSION

Pathophysiology and Classification of Chronic Rhinosinusitis

The pathophysiology of CRS is a complex process. CRS occurs due to disruption of the nasal mucosa barrier, activation of the immune system, and changes in the structure of sinus tissue that occur chronically.16 Under normal conditions, the nasal mucosa and sinuses function as the first defense against microorganisms and environmental particles through the integrity of the epithelium, mucus, and mucociliar mechanisms that play a role in cleaning pathogens. In CRS, there is a disruption of the function of the epithelial barrier so that the permeability of the mucosa increases. Therefore, pathogens, allergens, and environmental particles penetrate the epithelial layer more easily. This barrier damage then triggers a local immune response and a chronic inflammatory process occurs in the sinus mucosa (Bolger et al., 2007; Plaza et al., 2011).

The damaged epithelium will release various inflammatory mediators that act as an early signal for immune system activation. Epithelial cytokines such as interleukin-25, interleukin-33, and thymic stromal lymphopoietin will stimulate the activation of innate immune cells, especially innate lymphoid cells type 2. The activation of these cells then leads to the occurrence

of a type-2 inflammatory response which is the main mechanism in most CRSwNP cases. Type-2 inflammation is characterized by the activation of type-2 helper T cells, eosinophils, mast cells, as well as increased production of cytokines such as IL-4, IL-5, and IL-13.18 These cytokines have an important role in maintaining chronic inflammatory processes in the sinus mucosa.

IL-5 plays a role in the proliferation, differentiation, and activation of eosinophils. The activated eosinophils migrate to the sinus mucosal tissue and release various cytotoxic mediators such as major basic proteins and eosinophil cationic proteins. This mediator causes damage to epithelial tissue and amplifies the inflammatory processes that have already occurred. At the same time, IL-4 and IL-13 stimulate B cells to produce immunoglobulin E (IgE) as well as increase mast cell activity. The two cytokines also increase mucus production by goblet cells in the nasal mucosa resulting in mucus hypersecretion that contributes to the symptoms of nasal obstruction and rhinorhea in CRS patients. This long-lasting inflammation leads to progressive mucosal edema that can eventually develop into the formation of nasal polyps (Chaaban et al., 2018; Cutler et al., 2013; Levy et al., 2021).

Although type-2 inflammation is the dominant mechanism in CRSwNP, not all CRS have the same inflammatory pattern. In some patients, particularly in CRSsNP, inflammation may be dominated by different immune patterns, such as type-1 inflammation mediated by type 1 helper T cells and interferon-γ, or type-3 inflammation related to type 17 helper T cell activity and IL-17 production. Type-3 inflammation is often accompanied by neutrophil infiltration and is more related to chronic bacterial infections. This variation in inflammatory pattern shows that CRS is a heterogeneous disease and consists of various different immunological endotypes. These endotype differences also explain why patients' responses to therapy can vary greatly.

The role of eosinophils in the pathophysiology of CRS becomes very important because these cells are not only markers of type-2 inflammation but also play a direct role in tissue damage. Research shows that high eosinophils in sinus mucosal tissue correlates with a higher degree of disease severity as well as a greater risk of recurrence after endoscopic sinus surgery. In many classifications, more than ten eosinophils per microscope field of view are often used as indicators of type-2 inflammation of sinus tissue.

Chronic inflammation in CRS not only affects the mucosa but also causes changes in tissue structure referred to as remodeling. Tissue remodeling includes thickening of the mucosa, hyperplasia of the mucous glands, fibrosis, and the formation of nasal polyps. In severe and refractory cases of CRSwNP, chronic inflammatory processes can also lead to neo-osteogenesis, which is the formation of new bone on the sinus wall. This process is associated with increased expression of cytokines such as transforming growth factor beta-1 (TGF-β1) found in the sinus bone tissue of CRSwNP patients. Research shows that TGF-β1 derived from eosinophils can stimulate bone mineralization through increased alkaline phosphatase activity. This suggests that chronic eosinophilic inflammation not only causes mucosal changes but can also trigger bone remodeling in the paranasal sinuses.

In addition, the pathophysiology of CRS is also closely related to inflammatory diseases of the lower respiratory tract, specifically asthma. Both diseases have similar immunological mechanisms, especially type-2 inflammation mediated by eosinophils and Th2 cytokines. CRS and asthma are therefore often considered to be part of the same disease spectrum in the concept of "global airway disease", where inflammation occurs simultaneously in the upper and lower airways. This relationship explains why many patients with CRSwNP also have comorbid asthma. Overall, the pathophysiology of CRS is a multifactorial process involving impaired epithelial barrier function, activation of innate and adaptive immune responses, eosinophil

infiltration and production of inflammatory cytokines, as well as structural changes in the mucosa and sinus bones (Bachert et al., 2019; Sedaghat, 2020; Stevens et al., 2016).

Functional Endoscopic Sinus Surgery (FESS)

Functional Endoscopic Sinus Surgery (FESS) is a surgical procedure on the paranasal sinuses that is performed using an endoscope through the nasal cavity with the main goal of restoring ventilation and physiological drainage of the sinuses. The concept of FESS was first developed based on the understanding that most cases of chronic sinusitis are related to disorders of the osteomeatal complex, which is an important area in the meatus medius where the frontal, maxillary, and anterior ethmoid sinuses are emptied. If this area is obstructed due to mucosal edema, polyps, or anatomical changes, sinus ventilation will be disrupted and secretions will be trapped, triggering chronic inflammation. Therefore, the main goal of FESS is not only to remove pathological tissue but also to open the sinus' natural drainage pathway so that mucociliary function can return to normal.

Before surgery, patients usually undergo a thorough evaluation that includes a nasal endoscopy examination and a CT scan of the paranasal sinuses. CT scans are very important because they provide a detailed picture of the anatomy of the sinuses and the extent of the disease, while also helping to identify anatomical variations that can increase the risk of complications during surgery. Surgery planning is carried out based on the distribution of disease on the CT scan, so that the scope of surgical procedures can be adjusted to the condition of each patient.

FESS surgery is usually performed under general anesthesia. After the nasal cavity is visualized with an endoscopy, the first step that is often performed is uncinectomy, which is the removal of the unsynaptic process. This structure is part of an osteomeatal complex that can inhibit access to the maxillary sinus ostium. By removing the unsynatus process, the surgeon can open access to the maxillary sinus ostium and the ethmoidal infundibulum area. This is an important step because it opens a pathway to improve maxillary sinus drainage (Cai et al., 2022; Han et al., 2021).

After an uncinectomy is performed, the next step is usually a maxillary antrostomy, which is endoscopic enlargement of the maxillary sinus ostium. The goal of this procedure is to improve maxillary sinus ventilation and allow secretions trapped inside the sinuses to exit more effectively into the nasal cavity. In patients with chronic sinusitis, the sinus mucosa often experiences edema and excessive mucus production so that the sinus ostium becomes blocked. By widening the sinus ostium, the mucous clearance process by the mucociliary mechanism can resume better.

In many cases of CRS, inflammation also involves ethmoid cells, so an ethmoidectomy is performed. At this stage, the inflamed anterior ethmoid cells are opened and cleaned using endoscopic instruments. If the disease also involves the posterior ethmoid, the procedure can be continued by opening the posterior ethmoid cells until they reach the basal lamina. The goal of ethmoidectomy is to remove inflammatory tissue that blocks sinus ventilation and create a space that allows mucous drainage to take place normally.

If the sphenoid sinuses are also involved in the inflammatory process, a sphenoidotomy, which is the opening of the sphenoid sinus ostium, can be performed. This procedure is performed with great care because the sphenoid sinuses are located close to vital structures such as the internal carotid artery and optic nerve. By opening the sphenoid sinus ostymus, this sinus ventilation can be restored so that chronic inflammation can be reduced.

In some cases of CRS involving the frontal sinuses, a frontal sinusotomy is performed to open the drainage pathway of the frontal sinuses to the nasal cavity. The frontal sinuses have

a very complex anatomy so this procedure requires an excellent understanding of anatomy. The goal remains the same, which is to improve sinus ventilation and allow mucus to exit physiologically.

During the FESS procedure, surgeons must be very careful because the paranasal sinuses are located very close to important structures such as the orbita and base of the crania. Serious complications such as orbital injury or cerebrospinal fluid leakage can occur if the dissection is too deep or the direction of the instrument is imprecise. Therefore, in many modern surgical centers, image-guided navigation systems are used, which are CT scan-based navigation systems that help surgeons determine the position of the instrument in real-time during surgery.

After surgery is complete, patients typically undergo postoperative care that is critical to the long-term success of FESS. Postoperative therapy generally includes nasal irrigation with saline solution to clear secretions and debris, as well as the use of intranasal corticosteroids to reduce mucosal inflammation. In some patients with severe type-2 inflammation, additional therapies such as systemic corticosteroids or biological therapies may be given. This postoperative treatment is important because FESS does not eliminate all of the underlying inflammatory processes in CRS, but rather improves the anatomical condition of the sinuses so that medical therapy can work more effectively.

Thus, FESS can be understood as a procedure that focuses on the restoration of the physiological function of the sinuses, rather than simply the removal of diseased tissue. This approach allows the sinuses to return to good ventilation and optimal mucociliary function, so that chronic inflammation can be controlled and the patient's symptoms can improve significantly.

Sinuplasty Balloon

BSP is a minimally invasive sinus surgery technique developed as an alternative or complement to FESS in the management of CRS. This technique was first introduced in the early 2000s as a catheter-based procedure aimed at improving sinus ventilation by dilating the sinus ostium without removing bone or mucosal tissue. This approach is based on the principle that in many cases of CRS, major disturbances occur in the sinus drainage pathways, especially in areas of the osteomeatal complex, so that by reopening the sinus physiological function can be restored.

In the sinuplasty balloon procedure, a flexible catheter that has a small balloon at the end is inserted into the nasal cavity using an endoscopic guide. After the catheter reaches the narrowed or obstructed sinus ostium, the balloon is then gradually expanded to cause dilatation of the sinus ostium. This balloon inflation provides radial pressure on the bone wall around the ostium so that micro remodeling of the sinus bone structure occurs without having to cut or remove the tissue. Once dilation is achieved, the balloon is deflated and the catheter is removed, while the dilated sinus ostium remains open so that sinus ventilation and drainage can proceed more normally.

Technically, this procedure usually begins with visualization of the nasal cavity using endoscopy to identify important anatomical structures such as the konka media and the meatus medius region. Once the location of the sinus ostium is determined, a guide catheter is inserted towards the target ostium. Through this catheter, a flexible guidewire is inserted that is directed into the sinuses to be treated, for example the maxillary, frontal, or sphenoid sinuses. Once the position of the guidewire is confirmed by endoscopic visualization or navigational system assistance, the catheter balloon is inserted along the guidewire path until it reaches the blocked sinus ostium. The balloon is then gradually inflated with a certain pressure, causing the widening of the sinus ostium and opening up the previously narrow drainage pathways. This

process does not significantly damage the mucosa because dilation occurs slowly and controlled. Once the balloon is removed, the sinus drainage pathway remains open so that previously trapped secretions can flow out better.

The main advantage of balloon sinuplasty over traditional sinus surgery techniques is the lower level of invasiveness. Since this procedure does not involve extensive tissue resection, the tissue trauma that occurs is relatively minimal so that there is usually less intraoperative bleeding and the mucosal healing process is faster. In addition, mucosal preservation is very important because the sinus mucosa has a mucociliary clearance system that it functions to clean secretions and foreign particles from the sinuses. By maintaining mucosal integrity, mucociliary function can be maintained so that the risk of disease recurrence can be reduced.

Although it has many advantages, sinuplasty baloon cannot be used in all cases of CRS. This technique is most effective in patients with relatively mild to moderate CRS, especially in cases without nasal polyps and without complex anatomical abnormalities. In patients with more severe diseases, such as extensive nasal polyps, osteitis, or very severe inflammation of the mucosa, simple balloon dilatation is often not enough to overcome sinus obstruction. In these conditions, FESS is still necessary to remove pathological tissue and improve sinus ventilation more extensively.

Thus, balloon sinuplasty is an important innovation in the field of modern rhinology because it provides a more conservative surgical therapy alternative and focuses on the preservation of sinus physiological function. By reopening the sinus drainage pathway through natural ostium dilatation without tissue resection, this technique allows the restoration of sinus ventilation while maintaining the mucosal integrity that is essential for the upper airway defense system.

However, its inability to eliminate substantial inflammatory tissue limits its application to a wider range of diseases, and several systematic reviews highlight the need for careful patient selection[14],[15]. The inclusion criteria in almost all studies on BSP are often limited to patients with frontal, maxillary, or sphenoid sinus disease, while patients with massive nasal polyposis or severe ethmoid disease are excluded from pure BSP studies. In the context of indications, EPOS states that sinus balloons are best used in CRSsNP patients who have mild sinus ostine obstruction and relatively simple sinus anatomy. In this condition, the main problem is usually a narrowing of the sinus drainage pathway, especially in the maxillary sinus or frontal sinuses, so that mechanical dilation using balloons can improve ventilation and mucus flow without the need for tissue resection.1 This technique may also be considered in patients with sinus disease that is limited to one or two sinuses and is not accompanied by extensive mucosal inflammation. In some cases, balloon sinuplasty may also be used as part of a combination procedure with FESS, primarily to help widen a specific sinus ostym without significantly increasing tissue trauma. This approach is in line with the concept of modern sinus surgery that emphasizes the preservation of the mucosa and the restoration of the physiological function of the sinuses.

However, EPOS also confirms that sinuplasty balloons have limitations and cannot be used in all cases of CRS. This technique is generally not recommended in patients with extensive CRSwNP, as there is significant proliferation of polypoid tissue as well as more complex mucosal inflammation.1 In such cases, ostial dilatation alone is not enough to address sinus obstruction, so more extensive surgical procedures such as FESS are required to remove polyp tissue and thoroughly clean the sinuses.

Thus, EPOS views balloon sinuplasty as an additional technique in modern sinus surgery that may provide benefits to CRS patients without polyps with mild ostial obstruction. However, this technique is not intended to replace the role of FESS in more complex diseases,

but rather as part of a more individualized surgical approach focused on preserving sinus mucosal function.

Sino-Nasal Outcome Test (SNOT-20 / SNOT-22 / SF-36)

Both FESS and BSP showed significant improvements in patient-reported symptom severity and quality-of-life measures such as SNOT-20/22,8,9 Randomized clinical trials comparing balloon dilatation and FESS have shown a reduction in clinically meaningful SNOT scores in both groups, often without statistically significant differences in the selected mild to moderate CRS population.13 Based on a meta-analysis Sinha et al showed that both procedures provides significant symptom improvement from baseline. Statistically, no clinically significant differences were found between BSP and FESS in SNOT-20 scores at 6, 12, to 24 months of observation.24 Even from the REMODEL RCT study, these symptomatic SNOT score changes occurred from the beginning of follow-up and persisted up to 24 months after the action.

The magnitude of symptom improvement in the BSP group and the FESS group was almost the same, so that BSP was not declared inferior to FESS in improving the symptoms of CRS patients.26 A comparative study by Abhishek et al, showed significant symptom improvement both after surgery compared to before surgery based on SNOT-22 scores. In the conventional FESS group, the average SNOT-22 score decreased from about 55.7 before surgery to 28.4 six months after surgery. In the BSP group, the score decreased from 56.1 to 21.2. This decrease in score was statistically significant $p<0.001$.27 The cohort study of Abreu et al, also showed details of a statistically significant improvement in symptom improvement in each component of SNOT-20 in CRS patients who underwent BSP.28 In a prospective multicenter study of 203 patients with refractory CRS undergoing BSP in clinics under local anesthesia, 82.3% of patients rated this procedure as well tolerated, and there was a significant improvement in the SNOT-20.29 score of Abhishek et al, as well as a general quality of life assessment using the Short Form 36 (SF-36) questionnaire. The SF-36 assessment found that the BSP group had a higher quality of life score than the FESS group at six months after surgery.27 This suggests that BSP not only improves symptoms, but also has a better impact on patients' quality of life.

Complication Levels

BSP generally has lower perioperative morbidity, including reduced intraoperative bleeding and postoperative discomfort.12,14 Complications of postoperative bleeding were also studied by Abhishek et al, finding 4% in the BSP group and 12% in the FESS group.27 Both procedures were considered safe with a low complication rate. BSP is associated with a minimal risk of bleeding because no tissue is removed. Barla et al in their cohort study calculated the amount of intraoperative bleeding in the BSP group to be only 22.3 ± 9.4 mL, while in FESS 84.6 ± 21.3 mL, this result differed significantly with $p < 0.001$.30 The study of Abreu et al found no major complications in BSP, such as: heavy bleeding, cerebrospinal fluid leakage and orbital injury.

Ostial Sinus Patency and Revision Rate

Evidence on the revised operating numbers is still mixed. Several comparative cohort studies showed similar revision rates between BSP and FESS in selected populations.15 The rate of revision surgery after 12 months was reported to be very low and comparable in both groups, which was about 1.4% for BSP and 1.7%.15 Remodeling research showed

that the number of postoperative debridement actions was significantly less in the BSP group than in the FESS group. In addition, sinus ostentation at 12 months was more than 90% in both groups, with no statistically significant differences. The revised surgery rate was also low in both groups, at about 2.7% in the BSP and 6.9% in the FESS at the 18-month follow-up, and the difference was not statistically significant.

Barla et al explained that at 12-month follow-up, revision surgery rates were found in 5% of BSP patients and 3.3% of FESS patients, with $p = 0.65$, so the difference was not statistically significant.29 In a study by Abreu et al that examined the effectiveness of BSP, it was found that of the 24 sinus ostiums that were dilatated, as many as 22 ostiums (92%) remained open (patented) at follow-up.28 A multicenter registry study by Levine et al involved 1,036 patients at 27 ENT service centers In this study Balloon sinuplasty was performed on 3,276 sinuses with an average follow-up of 40 weeks. The results showed a revision rate of only about 1.3% of dilated sinuses. Another study evaluating 115 patients in the CLEAR study showed that sinuplasty balloons had a success rate of about 97% in opening the ostentatious sinus that had become obstructed.

Lund-Mackay Score

The study objectively assessed the development of CRS from radiological outcomes using the Lund-Mackay score. Abreu at al reported sinus CT scan scores showed significant improvement after the BSP action. The average score before BSP was 5.2 ± 2.7 and the score after BSP was 1.2 ± 1.1. There was an average decrease of about 4.2 points, with $p = 0.001$.28 When compared to the FESS group, there was a greater improvement. The average score decline was 5.6 ± 2.1 on BSP and 6.8 ± 2.4 on FESS, with $p = 0.04$, indicating a significant difference.

Recovery Time and Cost

BSP has the advantage of shorter operating times and faster recovery of normal activities compared to traditional FESS. BSP procedures can reduce costs related to anesthesia and the use of the device. In the Remodel study, patients who underwent BSP experienced a much faster recovery time compared to patients who underwent FESS, which was about 1.7 days in BSP compared to 5 days in FESS.26 The Remodel meta-analysis also showed that after undergoing BSP, patients experienced a decrease in the number of days they did not go to work or school, a decrease in the number of days they had to stay at home due to sinusitis symptoms, decrease in visits to health facilities, decrease in the number of acute infections, and decrease in antibiotic use.26 All of these changes are statistically significant.

Cost-effectiveness comparisons between BSP and FESS are still mixed. Balloon dilation may reduce perioperative costs but involve higher cost of disposable devices.4 FESS may demonstrate superior cost effectiveness in a wide range of diseases due to reduced feasibility of revision surgery.24

Patient Selection and Clinical Decision Making

Proper patient selection remains central to optimizing surgical outcomes[6]. Limited, anatomically localized CRS without diffuse polyposis may perform BSP action.13 In contrast, patients with extensive ethmoid disease, CRSwNP, asthmatic comorbidities, aspirin-aggravated respiratory disease (AERD), or inflammation-type

2 tall ones often benefit from tissue lift operations to

reduces the inflammatory load. 17.31 Radiological severity assessed using the Lund–Mackay score correlates with disease area and may support FESS in patients with high scores.32 Similarly, a high baseline SNOT-22 score may predict the need for a more comprehensive intervention.

CONCLUSION

The findings of this study indicate that both Balloon Sinuplasty (BSP) and Functional Endoscopic Sinus Surgery (FESS) are effective interventions in improving clinical outcomes for patients with chronic rhinosinusitis (CRS), particularly in terms of symptom reduction and quality of life as measured by standardized instruments such as SNOT-22. The comparative analysis demonstrates that BSP offers advantages as a minimally invasive procedure, including reduced intraoperative bleeding, shorter recovery time, and lower perioperative morbidity. Meanwhile, FESS remains the gold standard for more severe or complex CRS cases, especially those involving nasal polyps or extensive anatomical obstruction, due to its ability to remove pathological tissue and provide more comprehensive sinus drainage. Overall, both procedures show comparable effectiveness in selected patient populations, emphasizing that clinical decision-making should be individualized based on disease severity, anatomical considerations, and patient characteristics. For future research, it is recommended to conduct large-scale, multicenter randomized controlled trials with longer follow-up periods to further evaluate the long-term efficacy and durability of BSP compared to FESS, particularly in diverse CRS subtypes. Additionally, future studies should explore standardized patient selection criteria and incorporate advanced diagnostic tools such as biomarkers and imaging-based scoring systems to enhance precision in treatment planning. Economic evaluations comparing cost-effectiveness between BSP and FESS in different healthcare settings are also needed to support evidence-based policy decisions. Furthermore, integrating patient-reported outcomes with objective clinical measures will provide a more holistic understanding of treatment success, thereby contributing to the development of more personalized and optimized management strategies for chronic rhinosinusitis.

REFERENCES

Bachert, C., Han, J. K., Desrosiers, M., Hellings, P. W., Amin, N., Lee, S. E., Mullol, J., Greos, L. S., Bosso, J. V, Laidlaw, T. M., Fokkens, W. J., & Hopkins, C. (2019). Efficacy and safety of dupilumab in patients with severe chronic rhinosinusitis with nasal polyps (LIBERTY NP SINUS-24 and LIBERTY NP SINUS-52): Results from two multicentre, randomised, double-blind, placebo-controlled, parallel-group phase 3 trials. *The Lancet*, *394*(10209), 1638–1650. https://doi.org/10.1016/S0140-6736(19)31881-1

Bachert, C., Zhang, N., Hellings, P. W., & Bousquet, J. (2018). Endotype-driven care pathways in patients with chronic rhinosinusitis. *Journal of Allergy and Clinical Immunology*, *141*(5), 1543–1551. https://doi.org/10.1016/j.jaci.2018.03.004

Bolger, W. E., Brown, C. L., Church, C. A., Bhore, R., DeTineo, M., & Lanza, D. C. (2007). Safety and outcomes of balloon catheter sinusotomy: A multicenter 24-week analysis in 115 patients. *Otolaryngology–Head and Neck Surgery*, *137*(1), 10–20. https://doi.org/10.1016/j.otohns.2007.03.007

Cai, S., Xu, S., Lou, H., & Zhang, L. (2022). Comparison of different biologics for treating chronic rhinosinusitis with nasal polyps: A network analysis. *Journal of Allergy and Clinical Immunology: In Practice*, *10*(7), 1876–1886. https://doi.org/10.1016/j.jaip.2022.02.034

Chaaban, M. R., Rana, N., Baillargeon, J. G., Baillargeon, G., & Resto, V. (2018). Outcomes and revision rates following functional endoscopic sinus surgery in academic versus nonacademic settings. *Laryngoscope*, *128*(4), 838–843. https://doi.org/10.1002/lary.26853

Cutler, J. L., Bikhazi, N., Light, J., Truitt, T., & Schwartz, M. (2013). Standalone balloon dilation versus sinus surgery for chronic maxillary sinusitis: A prospective, multicenter, randomized, controlled trial. *American Journal of Rhinology & Allergy*, *27*(5), 416–422. https://doi.org/10.2500/ajra.2013.27.3918

Fokkens, W. J., Lund, V. J., Hopkins, C., Hellings, P. W., Kern, R., Reitsma, S., Toppila-Salmi, S., Bernal-Sprekelsen, M., Mullol, J., & Alobid, I. (2020). European Position Paper on Rhinosinusitis and Nasal Polyps 2020. *Rhinology*, *58*(S29), 1–464. https://doi.org/10.4193/Rhin19.406

Han, J. K., Bachert, C., Fokkens, W., Desrosiers, M., Wagenmann, M., Lee, S. E., Smith, S. G., Martin, N., Mayer, B., Yancey, S. W., Sousa, A. R., Chan, R., & Hopkins, C. (2021). Mepolizumab for chronic rhinosinusitis with nasal polyps (SYNAPSE): A randomised, double-blind, placebo-controlled, phase 3 trial. *The Lancet Respiratory Medicine*, *9*(10), 1141–1153. https://doi.org/10.1016/S2213-2600(21)00097-7

Hastan, D., Fokkens, W. J., Bachert, C., Newson, R. B., Bislimovska, J., Bockelbrink, A., & Bousquet, P. J. (2011). Chronic rhinosinusitis in Europe: An underestimated disease. *Allergy*, *66*(9), 1216–1223. https://doi.org/10.1111/j.1398-9995.2011.02646.x

Hopkins, C. (2009). Chronic rhinosinusitis: pathophysiology, presentation and management. *Rhinology*, *47*(2), 93–98. https://doi.org/10.4193/Rhin08.040

Hopkins, C., Browne, J. P., Slack, R., Lund, V., Topham, J., Reeves, B., & van der Meulen, J. (2009). The national comparative audit of surgery for nasal polyposis and chronic rhinosinusitis. *Clinical Otolaryngology*, *34*(5), 447–454. https://doi.org/10.1111/j.1749-4486.2009.01979.x

Levy, J. M., Marino, M. J., & McCoul, E. D. (2021). Balloon dilation of the paranasal sinuses for the treatment of chronic rhinosinusitis: A systematic review and meta-analysis. *Otolaryngology–Head and Neck Surgery*, *11*(2), 196–208. https://doi.org/10.1002/alr.22564

Orlandi, R. R., Kingdom, T. T., Hwang, P. H., Smith, T. L., Alt, J. A., Baroody, F. M., Batra, P. S., & Bernal-Sprekelsen, M. (2016). International Consensus Statement on Allergy and Rhinology: Rhinosinusitis. *International Forum of Allergy & Rhinology*, *6*(S1), S22–S209. https://doi.org/10.1002/alr.21695

Plaza, G., Eisenberg, G., Montojo, J., Onrubia, T., Urbasos, M., & O'Connor, C. (2011). Balloon dilation of the frontal recess: a randomized clinical trial. *Annals of Otology, Rhinology & Laryngology*, *120*(8), 511–518. https://doi.org/10.1177/000348941112000804

Ramakrishnan, V. R., Kingdom, T. T., Nayak, J. V, Hwang, P. H., & Orlandi, R. R. (2012). Nationwide incidence of major complications in endoscopic sinus surgery. *International*

Forum of Allergy & Rhinology, *2*(1), 34–39. https://doi.org/10.1002/alr.20101
Rudmik, L., & Smith, T. L. (2011). Quality of life in patients with chronic rhinosinusitis. *Current Allergy and Asthma Reports*, *11*(3), 247–252. https://doi.org/10.1007/s11882-011-0180-x
Sedaghat, A. R. (2020). Chronic rhinosinusitis. *American Journal of Rhinology & Allergy*, *41*(5), 299–304. https://doi.org/10.2500/aap.2020.41.190047
Smith, K. A., Orlandi, R. R., & Rudmik, L. (2015). Cost of adult chronic rhinosinusitis: A systematic review. *Laryngoscope*, *125*(7), 1547–1556. https://doi.org/10.1002/lary.25180
Stammberger, H. (1991). *Functional Endoscopic Sinus Surgery*. B.C. Decker.
Stevens, W. W., Schleimer, R. P., & Kern, R. C. (2016). Chronic rhinosinusitis with nasal polyps. *Journal of Allergy and Clinical Immunology: In Practice*, *4*(4), 565–572. https://doi.org/10.1016/j.jaip.2016.04.012