Review

Enhanced Evaluation of Bioresorbable Steroid-Releasing Stents and Corticosteroid-Infused Nasal Dressings in Postoperative Management of Chronic Rhinosinusitis

Morad Faoury *

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Enhanced Evaluation of Bioresorbable Steroid-Releasing Stents and Corticosteroid-Infused Nasal Dressings in Postoperative Management of Chronic Rhinosinusitis

Morad Faoury

Lewisham University Hospital; moradfaoury@gmail.com

Abstract: Introduction: Chronic rhinosinusitis (CRS) is a prevalent inflammatory condition of the nasal and paranasal mucosa that significantly impacts quality of life. Postoperative inflammation and polyp recurrence remain common despite advances in endoscopic sinus surgery (ESS), prompting interest in localized corticosteroid delivery systems. Methods: This review analyzes bioresorbable steroid-releasing implants and corticosteroid- impregnated nasal dressings, focusing on their pharmacologic mechanisms, safety, and clinical outcomes. A synthesis of findings from randomized trials and observational studies was performed, with emphasis on devices such as Propel™, NasoPore, Merocel, SinuBand FP, and gel-based dressings. Results: The Propel implant demonstrated robust evidence for reducing adhesions and inflammation with negligible systemic absorption. NasoPore and Merocel provided structural support and localized steroid delivery but lacked controlled-release kinetics. Gel-based dressings and SinuBand FP offered anatomic adaptability, with limited systemic effects. Some methods showed systemic steroid exposure in cortisol monitoring. Conclusion: Corticosteroid-releasing devices enhance ESS outcomes through localized therapy. While Propel is the most validated, other devices remain viable alternatives in specific clinical contexts. Comprehensive safety monitoring and standardized trials are essential to optimize their integration into postoperative care.

Keywords: chronic rhinosinusitis (CRS); endoscopic sinus surgery (ESS); bioresorbable steroid-eluting stents; corticosteroid-impregnated nasal dressings; propel sinus implant; nasal drug delivery; local corticosteroid therapy; sinonasal healing

1. Introduction

Chronic rhinosinusitis (CRS) is characterized by persistent inflammation of the nasal and paranasal sinus mucosa lasting more than 12 weeks [1]. It affects a significant portion of the global population—approximately 8.71%—and is associated with major negative impacts on quality of life, including facial pain, rhinorrhea, impaired olfaction, and nasal obstruction [2,3]. CRS is broadly categorized into two major clinical phenotypes: CRS with nasal polyps (CRSwNP) and CRS without nasal polyps (CRSsNP). These types exhibit distinct immunopathologic characteristics. CRSwNP is predominantly associated with type 2 helper T-cell (Th2)-mediated eosinophilic inflammation, often accompanied by elevated interleukin-5 (IL-5) levels. In contrast, CRSsNP is typically driven by neutrophilic inflammation linked to a Th1/Th17 immunologic response [4,5].

Initial treatment modalities include nasal saline irrigation, intranasal corticosteroids, short courses of systemic steroids, and antibiotics for bacterial superinfection. However, a subset of patients with moderate to severe CRS does not respond to maximal medical therapy and may require surgical intervention. Functional endoscopic sinus surgery (FESS) has become the standard surgical approach for CRS refractory to medical management. The objective of FESS is to restore sinonasal ventilation and mucociliary function by removing polyps and obstructions, and by widening sinus drainage pathways. [6–8]

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Despite advances in surgical technique, many patients continue to experience postoperative complications such as inflammation, adhesions, granulation tissue formation, and polyp recurrence. These issues frequently lead to additional interventions and may compromise surgical success [9–11]. Consequently, the incorporation of adjuvant pharmacologic strategies in the immediate postoperative period has become a key consideration in CRS management.

Topical corticosteroid therapy remains a cornerstone of postoperative care, but limitations in anatomical access—particularly to the frontal recess and ethmoid sinuses—can compromise drug delivery. To address these shortcomings, bioresorbable steroid-eluting implants and corticosteroid-impregnated nasal dressings have been introduced. These devices offer the dual benefit of sustained corticosteroid release and mechanical support to prevent middle turbinate lateralization and adhesion formation [12–14]. The Propel™ implant, developed by Intersect ENT, has gained regulatory approval and widespread clinical adoption due to its favorable safety and efficacy profile. Other systems—such as NasoPore, Merocel, SinuBand, and gel-based dressings—have been studied with variable results and less robust evidence.

This article provides a comparative evaluation of these technologies, examining their pharmacologic delivery mechanisms, clinical efficacy, safety profiles, and economic implications to inform optimal device selection in the postoperative management of CRS.

2. Methods

A comprehensive literature search was conducted using PubMed and Google Scholar to identify prospective and retrospective studies that investigated intraoperative corticosteroid placement during endoscopic sinus surgery (ESS). Various combinations of the following search terms were employed: “CRS,” “corticosteroid placement,” “ESS,” “Propel,” “bioabsorbable steroid eluting,” “NasoPore,” “Gelfoam,” “steroid-impregnated spacer,” “MeroGel,” “drug-eluting,” and “Merocel.” Studies focusing on corticosteroid placement without ESS or those conducted in outpatient or office-based settings post-ESS were excluded from the review.

Table 1. Summary of studies evaluating corticosteroid-releasing devices used post-ESS.

Study	Country	Device	Steroid	Design	Key Findings	Safety Profile
Han et al. (2012) [19]	USA	Propel™	Mometasone	Meta-analysis	↓ Adhesions (70%), ↓ Turbinate lateralization (75%), ↓ Re-intervention (35%), ↓ polyp recurrence (46%), ↓ oral steroid use (40%)	No systemic absorption; safe ocular profile confirmed by pooled ADVANCE I & II data
Murr et al. (2011) [15]	USA	Propel™	Mometasone	RCT	Local delivery shown to reduce inflammation without systemic absorption	Plasma mometasone undetectable; cortisol levels stable
Côté & Wright (2010) [14]	Canada	NasoPore	Triamcinolone	RCT	Improved Lund-Kennedy scores, ↓ mucosal edema, ↓ crusting and	No adverse events reported

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					synechiae at weeks 1 and 3	
Hong et al. (2013) [24]	Korea	NasoPore	Triamcinolone	RCT	↓ Inflammation; but transient adrenal suppression (↓ AM cortisol levels) in steroid group	Systemic steroid absorption observed
Xu et al. (2016) [27]	China	Gel dressing	Triamcinolone	RCT	↓ Synechiae, improved POSE score, faster mucosal recovery	No systemic data reported
Adriaensen et al. (2017) [31]	Netherlands	SinuBand FP	Fluticasone	RCT	↓ Polypoid changes at 30 and 60 days; improved mucosa; non-significant effect on edema and LK scores	No systemic or ocular adverse events reported

3. Corticosteroid-Eluting Devices: Comparative Evaluation

Propel™ Implant

The Propel™ sinus implant (Intersect ENT, Menlo Park, CA, USA) is the most rigorously studied corticosteroid-releasing device approved for postoperative use in CRS. Constructed from a bioabsorbable poly (lactic-co-glycolic acid) (PLGA) matrix, it is embedded with 370 µg of mometasone furoate and designed to provide both mechanical sinus stenting and sustained local corticosteroid release over approximately 30 days [15–18]. The device expands radially, maintaining sinus patency while eluting its drug payload directly to the healing mucosa.

The ADVANCE I and II trials were pivotal in demonstrating the clinical efficacy of the Propel device. In ADVANCE I, statistically significant reductions were noted in the need for postoperative interventions and inflammation scores. ADVANCE II employed an intra-patient control design and confirmed improvements in middle turbinate stabilization, reduction in adhesion formation, and fewer instances of polyp recurrence [16,19].

These patients had Sino-nasal CRS, and they either had nasal polyposis or did not have nasal polyposis. There were some commonalities among the trials; nevertheless, there were also modest differences in the concurrent drug regimens. To be more specific, Murr et al. [15] forbade the use of oral steroids for fourteen days before ESS, but Marple et al. [16] did not prescribe any restrictions of this kind. The use of oral steroids within the first thirty days after surgery was not permitted in either of the trials considered. Every patient was given a course of perioperative antibiotics that lasted for fourteen days. Han et al. [19] conducted a meta-analysis that emphasized the clinical outcomes of 148 patients who participated in both trials under consideration. The combined results showed that by the thirty-first day after surgery, the implant was related to a percentage decrease of seventy percent in adhesion development and a percentage reduction of seventy-five percent in middle turbinate lateralization. Additionally, there was a considerable decrease in the requirement for postoperative treatments, which was reduced by 35%, the lysis of adhesions was reduced by 51%, and the prescriptions for oral steroids were reduced by 40%. Lastly, there was a proportional decrease of 46% in the number of cases with frank polyposis. [19].

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Safety evaluations have shown that systemic absorption is negligible. Murr et al. assessed plasma levels of mometasone in patients receiving bilateral Propel implants and found them to be undetectable. Morning serum cortisol levels remained stable, and no patients exhibited signs of hypothalamic-pituitary-adrenal axis suppression, affirming the localized nature of drug delivery [15,17]. On the other hand, Marple et al. reported two adverse events, one of which included adhesions, and the other involved an infection. The evaluation of ocular safety was conducted by observing changes in lens opacity and intraocular pressure, and it was found that there were no statistically significant alterations observed [16]. Additional evidence of the implant's ocular safety was shown in a different research, which included the placement of the implant in both eyes [20]. Kennedy and others have emphasized the mechanical and pharmacologic synergy of the device in improving postoperative outcomes [21].

Propel has been adapted for various sinus anatomies, including the ethmoid sinus (standard Propel), the maxillary sinus (Propel Mini), and the frontal recess (Propel Contour). The consistent evidence base, FDA approval, and broad clinical adoption make Propel the gold standard for corticosteroid-eluting implants in CRS surgery. In 2011, the Food and Drug Administration (FDA) of the United States of America granted clearance to these devices after they demonstrated both systemic and ocular safety. The only devices that have been built particularly for the frontal sinus that have effectiveness data that has been published are the Propel Mini and the Propel Contour. Propel implants were shown to be cost-effective for the management of patients with chronic respiratory distress syndrome (CRS) after ESS, according to an early cost analysis [22]. The subsequent assessments indicate that the lower expenses that are incurred as a result of fewer postoperative procedures are sufficient to compensate for the greater initial cost of the implants. It is essential to keep in mind, however, that the first experiments were financed by the industry, which suggests that there is a possibility of bias.

Long-term data further support its durability, with Matheny et al. reporting improvements in sinus patency and symptom control sustained up to 2 years postoperatively [23].

NasoPore

NasoPore is a biodegradable polyurethane nasal packing material widely used for hemostasis and structural support following ESS, the synthetic polyurethane nasal dressing has been applied to reduce the development of synechia and the amount of discomfort experienced after surgery. Its porous, compressible design permits easy application and gradual resorption. Although not originally developed for pharmacologic delivery, NasoPore has been repurposed as a vehicle for topical corticosteroids, most commonly triamcinolone acetonide [14,24].

A prospective randomized study by Côté and Wright demonstrated that triamcinolone-impregnated NasoPore significantly improved endoscopic healing outcomes compared to saline-treated controls. The steroid-treated group showed better Lund-Kennedy scores and less mucosal edema, synechiae, and crusting at 1 and 3 weeks postoperatively [14]. These findings were corroborated by Hong et al., who found reduced inflammation in the triamcinolone group but also reported temporary suppression of morning cortisol levels, suggesting systemic steroid absorption despite topical administration [24].

Unlike engineered drug-eluting implants, NasoPore's release of corticosteroids is non-uniform and influenced by moisture content and the pharmacologic properties of the steroid used. No pharmacokinetic studies have quantified drug levels in nasal tissue or systemic circulation after triamcinolone delivery via NasoPore, apart from the transient adrenal suppression noted by Hong et al. [24].

The lack of controlled release kinetics, variable degradation rates, and concerns about systemic exposure limit the role of NasoPore as a standardized drug-delivery platform. However, its availability, ease of use, and positive clinical findings suggest it may be a reasonable option in settings where Propel is not accessible, particularly in patients without contraindications to systemic corticosteroids. There were no adverse effects connected to implants that were reported in these

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investigations, which indicates that they are safe. The evaluation did not include any extra safety measures.

Merocel

Merocel is a non-resorbable polyvinyl acetate sponge traditionally used for nasal packing due to its compressibility and hemostatic properties. It is frequently employed to stabilize the middle turbinate and control postoperative bleeding, also used to avoid the development of synechia. Recent clinical interest has explored its role as a carrier for corticosteroids such as triamcinolone and budesonide [25,26].

Chang et al. conducted a controlled trial comparing budesonide-impregnated Merocel with untreated Merocel. The medicated group exhibited reduced mucosal crusting, inflammation, and improved endoscopic healing at 2- and 4-weeks post-surgery [25]. In a similar study, Sabarinath et al. demonstrated that triamcinolone-treated Merocel was associated with fewer adhesions, lower inflammatory scores, and a more favorable endoscopic appearance than standard packing [26].

However, Merocel must be manually removed postoperatively, which can be uncomfortable and potentially traumatic. Unlike bioresorbable implants, Merocel does not allow for sustained, controlled steroid release. Furthermore, no pharmacokinetic data are available to assess systemic absorption following steroid-impregnated Merocel use. While the clinical outcomes appear positive, the lack of safety data limits its broader adoption as a pharmacologic delivery system.

Nonetheless, its widespread availability and surgeon familiarity make medicated Merocel a viable adjunct in postoperative management, particularly in low-resource settings.

Gel-Based Dressings

Gel-based nasal dressings, including hyaluronic acid, carboxymethylcellulose, and calcium alginate derivatives, have been developed to optimize healing after ESS by providing hydration, hemostasis, and, when impregnated with corticosteroids, localized anti-inflammatory effects [27–29]. SinuFoam is a polysaccharide composed of carboxymethylcellulose that may be combined with a corticosteroid. A corticosteroid solution may be used to re-establish MeroGel, which is a bioabsorbable hyaluronic acid [27].

Xu et al. evaluated a biodegradable gel dressing infused with triamcinolone and observed improved endoscopic scores, reduced adhesions, and faster mucosal recovery in the treatment group compared to controls [27]. Similarly, Sow et al. conducted a randomized study comparing hydrocortisone gel dressing versus standard packing, showing improved epithelialization and mucosal appearance [28]. Hwang et al. also demonstrated benefits in synechiae reduction using medicated gel spacers [29].

However, these materials exhibit variability in steroid retention, mucosal absorption, and degradation rates. Moreover, systemic absorption and ocular safety have not been rigorously evaluated. Despite these limitations, gel-based dressings offer a biocompatible and atraumatic option for delivering steroids in the postoperative setting, particularly in revision cases or where minimal mechanical pressure is required.

SinuBand

SinuBand FP is a bioabsorbable nasal film composed of fibrinogen, measuring 2 cm by 2 cm, with one adhesive surface and a corticosteroid-impregnated side delivering 160 micrograms of fluticasone propionate. Preclinical rabbit studies have demonstrated minor local responses and peak corticosteroid concentrations within the first week of implantation [30].

Its conformability to targeted anatomical regions is one of its key advantages. However, clinical observations note difficulty inserting the implant into narrow ethmoid compartments due to its adhesive surface [31]. A randomized trial by Adriaensen et al. employed an inter-patient control design comparing SinuBand FP, non-medicated SinuBand, and untreated Merocel. SinuBand FP

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resulted in significantly fewer polypoid changes at 30 and 60 days, although no significant differences were found in postoperative edema or Lund-Kennedy scores [31]. The study reported no local, ocular, or systemic adverse effects.

Although only a single clinical trial has evaluated SinuBand FP to date, its unique design may reduce early postoperative occlusion of sinus drainage pathways relative to bulkier implants. Yet, its applicability in narrow sinus cavities remains challenging. The unilateral design of the study also precludes firm conclusions about systemic corticosteroid safety.

Overall, SinuBand FP appears to offer a promising balance between localized corticosteroid delivery and anatomic adaptability in select patients undergoing ESS for CRSwNP.

Adverse Effects and Safety Profiles

Safety profiles of corticosteroid-releasing implants and nasal dressings vary significantly depending on the device, steroid formulation, and delivery mechanism. The Propel implant has undergone rigorous safety evaluation, with multiple studies confirming undetectable plasma levels of mometasone and no suppression of serum cortisol [15]. Kennedy also reported low rates of complications and emphasized the safety of localized delivery without systemic spillover [21].

In contrast, Hong et al. observed adrenal suppression with triamcinolone-impregnated NasoPore, suggesting systemic absorption can occur even with presumed topical application [24]. No ocular complications or intraocular pressure changes were reported, though these parameters were not routinely monitored in most studies.

For Merocel, gel-based dressings, and SinuBand FP, systemic safety data remain limited. Most trials focused on local healing and endoscopic outcomes without evaluating serum corticosteroid levels, HPA axis integrity, or ophthalmologic parameters. This lack of standardized safety monitoring highlights a critical evidence gap, particularly given the potential for systemic effects with high-potency steroids or repeated use.

Local adverse events across all platforms were generally mild, including transient discomfort, crusting, epistaxis, and packing-related pain. No significant implant migration or mucosal necrosis was reported. Nonetheless, robust safety assessments remain essential, especially for newer or compounded steroid preparations.

Economic and Practical Considerations

Cost and practicality remain key considerations in the adoption of corticosteroid-releasing implants and dressings. The Propel implant, while clinically effective, incurs significantly higher upfront costs than traditional materials. However, economic analyses suggest that these costs may be offset by reductions in postoperative complications, fewer debridement, and lower revision surgery rates [22,32]. Rudmik and Smith conducted a cost-effectiveness analysis and found that bioabsorbable implants could be economically favorable in select patient populations [22].

In contrast, NasoPore, Merocel, and gel-based dressings are more cost-effective and widely available. Their ease of use and familiarity among surgeons make them attractive alternatives, especially in resource-limited settings. However, the absence of FDA approval for pharmacologic delivery, inconsistent efficacy, and lack of controlled release diminish their utility as standardized solutions.

SinuBand FP offers a middle ground between cost and innovation, but more data are needed on its long-term safety and economic value. Ultimately, device selection should be tailored based on clinical context, anatomical considerations, and healthcare system constraints.

4. Discussion

The integration of corticosteroid-releasing devices into postoperative care has markedly improved surgical outcomes in chronic rhinosinusitis. The Propel implant remains the most evidence-supported and widely used platform, with Level 1A data demonstrating significant

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reductions in adhesions, inflammation, and revision procedures Its safety, bioresorbable, and anatomical variants contribute to its strong clinical adoption. Reports of drug-eluting biomaterials that are intended for placement in office settings are not included in this study. Both the Sinuva (Intersect ENT) and the LYR-210 implants (Lyra Therapeutics) are examples of these technologies. Both of these implants have shown therapeutic improvements for patients who have chronic recurrent sinusitis (CRS).

Alternative devices like NasoPore and Merocel have shown potential when used with corticosteroids, improving short-term healing indices such as crusting and edema [14,24–26]. However, systemic steroid absorption and a lack of controlled release mechanisms limit their standardization. Similarly, gel-based dressings and SinuBand FP have yielded promising results in individual trials, but require further evaluation of safety and drug kinetics [27–29,31].

From an economic perspective, while Propel involves a higher initial investment, its clinical efficiency and ability to reduce follow-up care may justify its cost in appropriately selected patients [22,32]. Nonetheless, the decision to use a specific device should consider patient anatomy, comorbidities, steroid sensitivity, and institutional resources. . In spite of the fact that the off-label usage of corticosteroid-impregnated packing materials shows extremely positive outcomes, more research that is more thorough is required in order to establish their safety profiles on a more comprehensive level.

As newer drug-eluting technologies and combination devices (e.g., steroid-antibiotic hybrids) emerge, rigorous evaluation of their safety, efficacy, and cost-effectiveness will be essential. Greater standardization in study design, consistent use of objective endpoints, and inclusion of safety biomarkers are needed. In particular, systemic absorption, endocrine disruption, and ocular risk must be systematically assessed in all drug-delivery devices intended for sinus use. In conclusion, For the post-operative treatment of CRS patients to be exceptionally effective, it is vital to have a full awareness of the long-term advantages and downsides of different technologies.

5. Conclusion

In the treatment of CRS, intraoperative corticosteroid delivery techniques have evolved to provide safe and effective methods for enhancing postoperative healing of the sinonasal mucosa following ESS. Among these, the Propel™ implant has the most robust supporting evidence, with multiple Level 1A studies confirming its clinical efficacy and safety. It remains the only FDA-approved corticosteroid-releasing implant, with established systemic and ocular safety.

SinuBand has also demonstrated favourable safety outcomes, while other corticosteroid-eluting devices—such as NasoPore, Merocel, gel-based dressings —are often used off-label. Although their efficacy is supported by a range of studies, concerns remain about unequal drug distribution and a lack of thorough safety evaluations, particularly regarding ocular and adrenal effects. A comprehensive review of the literature highlights a diverse array of technologies with varying levels of effectiveness and evidence quality.

Future research should prioritize head-to-head comparisons, detailed pharmacologic profiling, and safety validation—especially as emerging options like Sinuva and LYR-210 gain traction in office-based management of recurrent CRS. Ultimately, optimizing postoperative care for CRS hinges on individualized therapy informed by high-quality evidence and a clear understanding of each device's risk-benefit profile.

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