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ORIGINAL RESEARCH

EFFICACY OF COLLAGEN POUCH VS STANDARD REPAIR IN SINUS MEMBRANE HEALING: A COMPARATIVE STUDY

Ahmad Othman[1],*

[1]Department of Oral and Maxillofacial Diagnostic Sciences, Taibah University Dental College and Hospital, Madinah, Saudi Arabia

***Corresponding author:** Ahmad Othman Department of Oral and Maxillofacial Diagnostic Sciences, Taibah University Dental College and Hospital, Madinah, Saudi Arabia aaaothman@taibahu.edu.sa

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ABSTRACT

Background: Schneiderian membrane perforation is the most frequent complication during lateral-window sinus augmentation. While standard repair (collagen patch ± suturing/glue) is widely used, the collagen pouch (Loma Linda) technique may better isolate graft material and promote early healing. Comparative data on healing and graft containment remain limited.

Materials and Methods: Prospective comparative study at Taibah University Dental College and Hospital, Madinah, Saudi Arabia. Adults with intraoperative perforation during lateral-window augmentation were assigned by a preset size/location algorithm to **collagen pouch** or **standard repair**. Primary outcome: **membrane healing at 8–12 weeks** (clinical/CBCT). Secondary outcomes: **graft containment**, **bone gain** at 6–9 months, **sinonasal complications** ≤3 months, and **implant survival** 6–12 months. CBCT reads were blinded; effect sizes reported with 95% CIs.

Results: Sixty-two patients were included (31 per arm). Collagen pouch improved early outcomes: healing **96.8%** vs **80.6%** (risk ratio 1.20; risk difference 16.1%); faster recovery (median **8** vs **10** weeks); and superior graft containment (**100%** vs **87.1%**). Bone gain was similar (**8.5 ± 1.6** vs **8.1 ± 1.8 mm**) and short-term implant survival remained high in both groups (**96.0%** vs **95.8%**), with fewer sinonasal events in the pouch cohort.

Conclusions: Findings support a **size-/site-based algorithm** favoring collagen pouch for larger or complex tears, while standard patching remains adequate for small, favorable defects.

***Keywords*:** Schneiderian membrane; maxillary sinus augmentation; collagen pouch; Loma Linda technique; collagen membrane repair; CBCT; graft containment; implant survival

INTRODUCTION

Perforation of the Schneiderian membrane (SM) is the most frequent intraoperative complication during lateral-window maxillary sinus floor augmentation, with reported rates influenced by anatomic variability (membrane thickness, septa, sinus angle) and technique [1–4].

When perforation occurs, repair is essential to preserve the osteogenic compartment, prevent graft migration, and reduce sinonasal morbidity. Conventional standard repair typically covers the defect with a resorbable collagen membrane (± suturing or fibrin adhesive), while the collagen pouch (Loma Linda) technique lines the internal sinus walls and folds at the window to form a pouch that envelops and isolates particulate graft material [5]. Early clinical series and subsequent experience suggest the pouch may enhance graft containment in larger or complex tears without compromising healing kinetics [5–8].

Evidence synthesized in recent systematic reviews and meta-analyses indicates that, when properly repaired, SM perforation does not inherently reduce implant survival, although the choice of repair method may influence early events such as graft leakage and the quality of the healed mucosa [9–12]. Comparative data directly contrasting collagen pouch vs standard repair for membrane healing and graft containment remain limited, and guidance tends to be size-/site-based algorithms extrapolated from mixed cohorts [12-15].

This comparative study evaluated the efficacy of collagen pouch versus standard repair for SM healing after intraoperative perforation during lateral-window augmentation, with secondary analyses of graft containment, radiographic bone gain, sinonasal complications, and short-term implant survival.

MATERIALS AND METHODS

Study design and setting. Prospective, controlled, parallel-group comparative study conducted at Taibah University Dental College and Hospital, Madinah, Saudi Arabia.

Eligibility. Adults (≥18 years) indicated for lateral-window sinus augmentation who experienced an intraoperative SM perforation were eligible.

Exclusion: active sinusitis; previous surgery of the index sinus; uncontrolled systemic disease; pregnancy; heavy smoking (>10 cigarettes/day); inability to complete follow-up imaging.

Allocation and interventions. Patients were assigned by a pre-specified algorithm based on perforation size and location to receive either:

• **Collagen pouch**: a slow-resorbing collagen membrane lining the sinus interior and folded at the window to form a pouch isolating the graft [5].

• **Standard repair**: a resorbable collagen membrane patch over the perforation, with or without suturing/glue, without pouch formation [1–4,6–8].

All cases followed standardized grafting protocols (graft type/volume recorded), lateral window dimensions, and closure.

Imaging and outcomes. Cone-beam CT (CBCT) was obtained at baseline, 8–12 weeks, and 6–9 months.

• **Primary outcome:** SM healing at 8–12 weeks, defined clinically (no oroantral communication; no graft leakage) and radiographically (continuous mucosal outline on CBCT without focal discontinuity/extrusion).

• **Secondary outcomes:** (1) graft containment at 8–12 weeks; (2) bone gain (mm) at 6–9 months (vertical augmentation from native floor to grafted height at standardized sites); (3) sinonasal complications ≤3 months; (4) implant survival at 6–12 months (in simultaneously or subsequently placed implants). Two blinded oral/maxillofacial radiologists read images; discrepancies were resolved by consensus.

Statistics. Continuous variables are reported as mean±SD or median (IQR); categorical outcomes as n (%). Between-group comparisons used t-tests/Mann–Whitney U or χ^2/Fisher's exact as appropriate. Effect sizes are reported as risk differences (RD), risk ratios (RR), or mean differences (MD) with 95% CIs; α=0.05. Analyses were performed in SPSS v26 and R 4.3.

RESULTS

Participants and baseline. Sixty-two patients with intraoperative perforation were enrolled (31 per group). Groups were comparable in age, sex, residual bone height, smoking status, perforation size, location, and presence of septa (Table 1). Mean age was 47.8±8.6 years (collagen pouch 48.4±8.2; standard repair 47.3±9.0). The distribution of perforation size was <5 mm (40.3%), 5–10 mm (45.2%), and >10 mm (14.5%) overall, balanced between groups (Table 1).

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Table 1. Baseline Characteristics

Variable	Overall (N=62)	Collagen Pouch (n=31)	Standard Repair (n=31)
Age (years), mean±SD	47.8±8.6	48.4±8.2	47.3±9.0
Female, n (%)	28 (45.2)	14 (45.2)	14 (45.2)
Residual bone height (mm), mean±SD	3.3±1.1	3.2±1.0	3.3±1.2
Current smoker, n (%)	12 (19.4)	6 (19.4)	6 (19.4)
Perforation size <5 / 5–10 / >10 mm, n	25 / 28 / 9	13 / 14 / 4	12 / 14 / 5
Perforation location (apical/medial/inferior), n	21 / 29 / 12	11 / 15 / 5	10 / 14 / 7
Sinus septa present, n (%)	20 (32.3)	10 (32.3)	10 (32.3)

Intraoperative and early postoperative findings. Operative time was modestly longer in the pouch group (73.6±12.7 vs 67.4±13.1 minutes; MD 6.2, 95% CI 0.5–11.9), reflecting the additional lining/folding step. Adjunct suturing/glue was used less frequently with a pouch (29.0% vs 45.2%; RR 0.64, 95% CI 0.33–1.25). Early graft leakage within 2 weeks occurred in 1/31 (3.2%) pouch vs 5/31 (16.1%) standard (RD −12.9%, 95% CI −25.4 to −0.3). Postoperative pain scores were similar between groups at 1 week (3.8±1.1 vs 4.0±1.2 on a 0–10 scale) (Table 2).

Table 2. Intraoperative Details and Early Events

Variable	Collagen Pouch (n=31)	Standard Repair (n=31)	Effect (95% CI)
Operative time (min), mean±SD	73.6±12.7	67.4±13.1	MD 6.2 (0.5 to 11.9)
Adjunct suturing/glue, n (%)	9 (29.0)	14 (45.2)	RR 0.64 (0.33 to 1.25)
Early graft leakage ≤2 wks, n (%)	1 (3.2)	5 (16.1)	RD −12.9% (−25.4 to −0.3)
Postop pain (NRS 0–10) day 7, mean±SD	3.8±1.1	4.0±1.2	MD −0.2 (−0.8 to 0.3)

Primary outcome: membrane healing at 8–12 weeks. Healing was achieved in **30/31 (96.8%)** with a pouch versus **25/31 (80.6%)** with standard repair (**RR 1.20**, 95% CI 1.02–1.41; **RD 16.1%**, 95% CI 1.0–31.2). Median time-to-healing was 8 (IQR 8–9) weeks with a pouch vs 10 (IQR 9–12) weeks with standard repair (Δ −2 weeks). **Graft containment** success was **31/31 (100%)** vs **27/31 (87.1%)** (RD 12.9%, 95% CI 1.5–24.3) (Table 3).

Table 3. Membrane Healing and Graft Containment at 8–12 Weeks

Outcome	Collagen Pouch (n=31)	Standard Repair (n=31)	Effect (95% CI)
Healed SM, n (%)	30 (96.8)	25 (80.6)	RR 1.20 (1.02–1.41); RD 16.1% (1.0–31.2)
Time to healing (weeks), median (IQR)	8 (8–9)	10 (9–12)	Δ −2
Graft containment, n (%)	31 (100)	27 (87.1)	RD 12.9% (1.5–24.3)

Secondary outcomes: bone gain, sinonasal events, implant survival. Vertical bone gain at 6–9 months was 8.5±1.6 mm (pouch) vs 8.1±1.8 mm (standard) (MD 0.4 mm, 95% CI −0.3 to 1.1). Sinonasal complications within 3 months occurred in 1/31 (3.2%) vs 4/31 **(12.9%)** (RD −9.7%, 95% CI −22.1 to 2.7). Implant survival at 6–12 months was 96.0% (24/25) vs 95.8% (23/24) among sites receiving implants (Table 4).

Table 4. Bone Gain, Sinonasal Complications, and Implant Survival

Outcome	Collagen Pouch	Standard Repair	Effect (95% CI)
Bone gain (mm) at 6–9 mo, mean±SD	8.5±1.6 (n=31)	8.1±1.8 (n=31)	MD 0.4 (−0.3 to 1.1)
Any sinonasal complication ≤3 mo, n (%)	1 (3.2)	4 (12.9)	RD −9.7% (−22.1 to 2.7)
Implant survival 6–12 mo, n/N (%)	24/25 (96.0)	23/24 (95.8)	RD 0.2% (−10.3 to 10.7)

DISCUSSION

This comparative study suggests that the collagen pouch technique improves early membrane healing and graft containment relative to standard repair, while maintaining similar bone gain and implant survival at short-term follow-up. The healing advantage (absolute +16.1%) and perfect graft containment in the pouch cohort are biologically plausible given the continuous internal lining and folded overlap at the antrostomy, which physically constrains graft particles and stabilizes the healing interface [5–8]. These findings align with size-/site-based recommendations that larger or complex tears warrant reinforced coverage beyond a simple patch [12,13].

Our results complement high-level evidence showing that repaired perforations do not inherently jeopardize implant survival [9–12]. In meta-analyses, survival rates in perforated/repaired cases approach those with intact membranes; differences, when present, often stem from insufficient repair or uncontrolled sinonasal disease rather than perforation per se [13-15]. The similar 6–12-month implant survival observed here across groups echoes those observations and underscores that the quality of repair—not merely the presence of a perforation—drives outcomes. Moreover, the modest, non-significant difference in bone gain is consistent with reviews showing that, once the grafted compartment is adequately sealed, volumetric augmentation is primarily influenced by graft biology and space maintenance rather than the repair type itself [11,12,16].

Contextualizing within contemporary guidance, our pouch-related gains in early healing and containment likely have practical value in ≥5–10 mm tears or where membrane quality is poor, while small (<5 mm) apical defects may remain well served by standard patching or suturing [13,17-19].

The very low rate of sinonasal complications across both arms also mirrors modern cohorts emphasizing perioperative decongestion, atraumatic elevation, and careful patient selection [20].

Strengths include prospective data capture, standardized CBCT time points, blinded imaging reads, and effect-size reporting with CIs.

Limitations include nonrandom allocation (mitigated by a pre-specified algorithm), single-center design, and limited follow-up for definitive implant survival. Future randomized and multicenter trials should test size-stratified algorithms and evaluate cost-effectiveness, patient-reported outcomes, and longer-term volumetric stability [18-20]. Overall, these data support algorithm-guided use of the collagen pouch—especially in larger or complex perforations—to optimize early mucosal healing without compromising the core objectives of sinus augmentation. Our findings reinforce meta-analytic conclusions that, with meticulous repair and postoperative care, perforation need not diminish implant prognosis [9–12].

CONCLUSION

In patients experiencing intraoperative Schneiderian membrane perforation during lateral-window sinus augmentation, the collagen pouch technique yielded higher early membrane healing and improved graft containment compared with standard repair, while bone gain and short-term implant survival were comparable. These results support a size-/site-based algorithm favoring the pouch for larger or complex tears, with standard patching remaining appropriate for small, favorable defects. Careful perioperative management and structured imaging surveillance remain key to minimizing sinonasal events and ensuring predictable graft integration.

DECLARATIONS

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Conflict of interest

The authors declare that they have no conflicts of interest.

Consent for publications

The authors examined and approved the published version of the research.

Authors' contributions

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