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Canalicular Injury: Comparison of Minimonoka Stent and Silicone Sling for Monocanalicular Intubation

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Abstract: ***Purpose**: Canalicular lacerations are a common adnexal injury, frequently associated with road traffic accidents, assaults, and falls. Primary repair with intubation is the standard of care to maintain lacrimal drainage patency. Several materials, including commercial stents and improvised substitutes, are available, but their comparative outcomes remain under evaluation. The present study aimed to compare clinical outcomes of monocanalicular intubation using Minimonoka stents versus silicone sling remnants in patients with traumatic canalicular lacerations. **Methodology**: This prospective, non-randomized, hospital-based interventional study was conducted at the Department of Ophthalmology, Datta Meghe Medical College, Nagpur. Twenty-four patients presenting with monocanalicular lacerations were included between July 2024 to July 2025. Twelve underwent repair with Minimonoka stents and twelve with silicone sling remnants. Detailed preoperative ocular and adnexal evaluation was performed, associated injuries were noted, and NCCT orbit was performed when orbital trauma was suspected. Surgeries were performed under local or general anesthesia depending on patient age and injury profile. Postoperatively, sutures were removed on day 10, stents after 4 weeks, and patients were followed for one month to evaluate anatomical and functional success. **Results**: The study included 24 patients (18 males, 6 females) with a mean age of 29.6 years (range: 2–63 years). Road traffic accidents were the most common cause of injury. Four cases required isolated canalicular repair, while two were combined with orbital fracture repair. Postoperatively, both groups experienced transient foreign body sensation, irritation, and watering during the first week, which subsided subsequently. No stent extrusion or long-term complications were observed in either group. Anatomical and functional success was comparable in both groups. **Conclusion**: Monocanalicular intubation using silicone rod remnants is a cost-effective and effective alternative to Minimonoka stents in traumatic canalicular lacerations.*

Keywords: Canalicular laceration, Monocanalicular intubation, Minimonoka stent, Silicone sling, Adnexal trauma

1. Introduction

Canalicular lacerations are frequently encountered injuries in adnexal trauma, particularly following road traffic accidents, assaults, and penetrating ocular injuries. The integrity of the lacrimal drainage system is critical for maintaining ocular surface health and preventing chronic epiphora. The standard of care involves primary repair of the lacerated canaliculus with stenting to maintain patency during healing.

Various stenting techniques have been described, including bicanalicular intubation with Crawford tubes and monocanalicular intubation using Minimonoka stents. However, commercial stents may not always be readily available or affordable in resource-limited settings. An alternative approach involves using silicone sling remnants as improvised stents, which are more cost-effective while providing similar outcomes. The present study aims to compare the clinical outcomes of Minimonoka stents and silicone sling remnants in the management of monocanalicular lacerations.

The lacrimal drainage system plays an essential role in maintaining ocular surface health and visual comfort. It consists of the puncta, canaliculi, common canaliculus, lacrimal sac, and nasolacrimal duct, which function together to channel tears into the nasal cavity. Among these structures, the canaliculi—particularly the lower canaliculus—are most vulnerable to injury because of their delicate anatomy and exposed position along the eyelid margin. Even minor trauma can disrupt their continuity and compromise tear drainage. Left untreated, such injuries often lead to chronic epiphora, recurrent conjunctivitis, and decreased quality of life, underlining the need for prompt recognition and repair [1].

Canalicular lacerations are relatively common injuries encountered in ophthalmic emergency and trauma services. They account for nearly 16–20% of eyelid lacerations in various series [2], with a higher prevalence in younger, active populations. The most frequent etiologies include road traffic accidents (RTAs), particularly involving two-wheelers in South Asia, followed by interpersonal assaults, accidental falls, animal bites, and sharp-object injuries [3]. With the rise in urbanization and increasing use of motorized vehicles, RTAs remain the dominant cause in India, responsible for more than 60% of cases reported in recent studies [4]. Pediatric cases are often caused by falls, sharp toys, or animal bites [5], while in rural communities, agricultural injuries contribute to the burden.

The clinical impact of canalicular trauma extends beyond physical discomfort. Persistent tearing can interfere with daily activities such as reading, driving, and outdoor work. Patients may also suffer cosmetic deformities, social

embarrassment, and emotional stress [6]. In pediatric cases, untreated canalicular obstruction risks amblyopia due to blurred vision from constant tearing [7]. Thus, timely surgical repair is both functionally and psychosocially significant.

Historically, canalicular injuries were challenging to repair due to the fine caliber of the canaliculus (0.3–0.5 mm) and its propensity for scarring. Early attempts at repair without stenting often failed, leading to stenosis and obstruction. The introduction of stenting techniques revolutionized outcomes, providing internal splints that maintained lumen patency during healing [1]. Initially, bicanalicular intubation with Crawford tubes or silicone rods was the mainstay. Although effective, these required retrieval of the stent through the nasal cavity, which could be technically demanding and sometimes associated with complications such as cheese-wiring of the puncta, granuloma formation, or nasal mucosal injury [8].

To overcome these issues, monocanalicular intubation techniques were developed. Among these, the Minimonoka stent, introduced by Fayet and colleagues, became widely popular due to its self-retaining plug design, which eliminated the need for nasal retrieval and reduced the risk of trauma to the uninvolved canaliculus [4]. Minimonoka stents have since been reported to achieve excellent anatomical and functional success, with minimal extrusion rates [9]. Their relative ease of insertion and patient comfort have further supported their adoption.

However, commercial stents such as the Minimonoka have limitations in resource-constrained settings. Their cost can be prohibitive, and availability is often inconsistent, particularly in smaller centers and government hospitals in developing countries [3]. In response, ophthalmic surgeons have explored indigenous alternatives, including the use of silicone sling remnants, intravenous cannulae, and prolene sutures, among others. Silicone sling material, in particular, offers several advantages: it is inexpensive, biocompatible, easily available in ophthalmic operating theaters, and capable of replicating the structural support of commercial stents [5].

Recent studies have compared commercial and improvised stents, reporting comparable outcomes in terms of anatomical patency and functional success. Ali et al. (2020) and Singh et al. (2021) demonstrated that silicone substitutes can provide effective results without added complications [2, 3]. This evidence has spurred interest in validating low-cost techniques, especially in countries like India, where trauma burden is high and healthcare resources may be limited.

Despite these encouraging reports, high-quality comparative data remain sparse. Most existing studies are retrospective or involve small sample sizes, and follow-up durations vary widely [9, 10]. Moreover, while commercial devices are generally standardized, indigenous alternatives differ in preparation and insertion technique, leading to variability in reported outcomes. Thus, prospective studies directly comparing Minimonoka stents with silicone sling remnants are valuable for establishing evidence-based recommendations.

From a public health perspective, cost-effectiveness is also a crucial consideration. The burden of ocular trauma in India disproportionately affects young adults—the most economically productive segment of the population [6]. Affordable yet effective interventions can help reduce both direct treatment costs and indirect socioeconomic losses. By validating alternatives to costly imports, ophthalmologists in developing countries can ensure wider access to sight-preserving care [7].

In this context, the present study was designed to prospectively compare the clinical outcomes of monocanalicular intubation using Minimonoka stents versus silicone sling remnants in patients with traumatic canalicular lacerations. We aimed to assess both anatomical and functional success, record postoperative complications, and highlight the feasibility of silicone sling remnants as a cost-effective alternative in routine clinical practice.

2. Methods

Study Design and Setting

This was a prospective, non-randomized, hospital-based interventional study conducted at the Department of Ophthalmology, Datta Meghe Medical College, Nagpur, Maharashtra, India. The study period extended from July 2024 to July 2025 , during which all patients presenting with monocanalicular lacerations following adnexal trauma were screened for eligibility. The study was approved by the Institutional Ethics Committee, and informed consent was obtained from all participants or their legal guardians in the case of minors.

Eligibility Criteria Inclusion criteria:

Patients of any age and sex presenting with monocanalicular lacerations caused by trauma. Patients willing to provide informed consent and adhere to follow-up protocols.

Exclusion criteria:

- Bicanalicular injuries
- Canalicular lacerations associated with severe eyelid avulsion or tissue loss precluding primary repair.
- Previous history of lacrimal surgery.
- Patients with severe ocular injuries leading to non-salvageable vision.

Preoperative Evaluation

All patients underwent a detailed history and clinical examination, which included:

Mechanism of injury (road traffic accident, assault, fall, animal bite, etc.). Time interval between injury and presentation.

Complete ocular examination, including visual acuity, anterior segment evaluation, and fundus examination where possible.

Adnexal examination to determine the extent of eyelid laceration, canalicular involvement, and associated orbital or periocular trauma.

Non-contrast CT (NCCT) of the orbit and brain was

performed when orbital fractures or intracranial injuries were suspected.

Surgical Technique

All surgeries were performed by experienced oculoplastic surgeons under aseptic conditions. The choice of anesthesia (local infiltration with 2% lignocaine and adrenaline or general anesthesia in children and uncooperative patients) was individualized.

1) Wound preparation: The lacerated edges of the eyelid were gently debrided and irrigated with balanced salt solution. The proximal and distal ends of the injured canaliculus were identified using a Bowman's probe.
2) Stent placement:
   - Minimonoka stent group (n=12): The Minimonoka stent, a monocanalicular silicone stent with a self-retaining plug, was introduced into the proximal cut end of the canaliculus. The stent was carefully advanced into the distal segment until the plug seated securely at the punctum. The design eliminated the need for retrieval through the nasal cavity.
   - Silicone sling group (n=12); A segment of silicone sling (commonly used for frontalis suspension) was trimmed to an appropriate length (20–25 mm) and beveled at the ends. Using a Bowman's probe as a guide, the silicone rod was inserted into the proximal and distal canalicular ends, ensuring smooth passage and alignment. The externalized ends were adjusted to rest comfortably at the punctum without tension.
3) Canalicular and wound repair: The canalicular mucosal edges were approximated using 7-0 or 8-0 polyglactin sutures under magnification. The eyelid skin and orbicularis were then closed in layers with 6-0 absorbable sutures.

Postoperative Care

Topical antibiotic-steroid eye drops were prescribed 4 times daily for 2 weeks. Oral antibiotics and analgesics were administered as required.

Patients were instructed to avoid eye rubbing, vigorous washing, or trauma to the surgical site. Skin sutures were removed after 7–10 days.

Stents were removed after 4 weeks, following confirmation of canalicular patency. Follow-up Protocol

Patients were reviewed on:

Postoperative day 1 (to assess wound healing and stent position). At 1 week (to monitor irritation, watering, or wound infection).

At 2 weeks (to check for extrusion, granuloma formation, or persistent epiphora). At 4 weeks (for stent removal).

Final evaluation at 1 month after stent removal.

At each follow-up visit, the following parameters were recorded:

Presence of watering, foreign body sensation, or discomfort. Condition of the stent (well-positioned or displaced). Integrity of wound healing and any associated complications. Outcome Measures

Anatomical success was defined as continuity of the repaired canaliculus without stent extrusion until removal. Patency was confirmed by irrigation of the lacrimal system with saline.

Functional success was defined as absence of epiphora and patient-reported symptomatic relief at 1 month following stent removal.

Statistical Analysis

Data was entered into Microsoft Excel and analyzed using the SPSS software. Descriptive statistics were calculated for demographic and clinical variables. Categorical variables such as postoperative complications were compared between the two groups using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.

3. Results

A total of 24 patients with monocanalicular lacerations were included in the study. Of these, 18 (75%) were male and 6 (25%) were female, with a male-to-female ratio of 3:1. The age of patients ranged from 2 to 63 years, with a mean age of 29.6 years. The highest incidence was observed in the third decade of life, accounting for 37.5% of cases, followed by the second decade (20.8%). Pediatric cases (≤10 years) comprised 3 patients (12.5%).

Etiology of Injury

Road traffic accidents (RTAs) were the most frequent cause, observed in 16 patients (67%). These injuries were most often sustained during two-wheeler accidents without protective headgear. Assault-related trauma accounted for 4 cases (16%), while accidental falls contributed to 2 cases (8%). Animal bites and miscellaneous sharp-object injuries were recorded in the remaining 2 patients (8%). The etiology distribution reflects the regional trauma pattern, with RTAs predominating in young adults.

Laterality and Canalicular Involvement

Injuries were almost equally distributed between the right and left eyes (13 vs. 11). The lower canaliculus was more frequently involved (20 patients, 83%) compared with the upper canaliculus (4 patients, 17%). No patient had simultaneous bicanalicular injury, as this was an exclusion criterion.

Associated Injuries

Four patients (16.7%) had isolated canalicular injuries. Two patients presented with concurrent orbital fractures, requiring additional repair during the same sitting. Other minor associated injuries included superficial lid lacerations and subconjunctival hemorrhage. None of the patients had globe rupture or optic nerve injury.

Surgical Outcomes

All patients underwent successful primary repair with either a Minimonoka stent (n=12) or a silicone sling remnant

(n=12). In both groups, stent placement was technically successful in all cases, and the stents remained in situ until planned removal at 4 weeks.

Minimonoka group: All 12 patients achieved anatomical continuity of the canaliculus. Transient foreign body sensation and mild irritation were reported in 9 patients during the first postoperative week, but these symptoms subsided with lubricants and reassurance. No patient developed granulomas or stent extrusion.

Silicone sling group: Similarly, all 12 patients achieved anatomical success. Eight patients reported transient irritation within the first week, which resolved spontaneously. No case of premature extrusion or secondary infection was recorded.

Postoperative Complications
Minor postoperative discomfort was the most common finding in both groups. Importantly, no case of stent displacement, extrusion, pyogenic granuloma, or canalicular stenosis was noted in either group. At the time of stent removal (week 4), all canaliculi were patent on irrigation.

Functional Success
At the 1-month follow-up after stent removal, all 24 patients (100%) reported absence of epiphora, indicating functional success. No difference in success rates was observed between the Minimonoka and silicone sling groups.

Comparative Analysis
Anatomical success:100% in both groups. Functional success:100% in both groups.

Complications: Transient irritation was slightly more frequent in the Minimonoka group (75% vs. 66.7%), but this difference was not statistically significant ($p>0.05$).

Table 1: Patient Demographics and Etiology

Variable	Value(n=24)
Mean age(years)	29.6 (2–63)
Male: Female	18:06
Etiology – RTA	16 (67%)
Assault	4 (17%
Fall	3 (13%)
Other trauma	1 (3%)

Table 2: Surgical and Postoperative Findings

Variable	Minimonoka (n=12)	Silicone sling (n=12)
Isolated canalicular repair	2	2
Combined with orbital fracture repair	1	1
Transient irritation (1st week)	9	8
Epiphora after 1 month	0	0
Stent extrusion	0	0
Anatomical success	12(100%)	12(100%)
Functional success	12(100%)	12(100%)

Narrative Interpretation
The results demonstrate that silicone sling remnants perform equivalently to Minimonoka stents in terms of anatomical patency and functional relief from epiphora. Both groups achieved excellent outcomes, with minimal transient complications and no long-term sequelae during the short-term follow-up period. The absence of major complications such as stent extrusion or canalicular obstruction further supports the safety of both techniques. Importantly, the cost-effectiveness and ready availability of silicone sling material enhance its clinical value, particularly in settings where commercial stents are not easily accessible.

4. Discussion

The present study compared the outcomes of Minimonoka stents and silicone sling remnants for monocanalicular intubation in patients with traumatic canalicular lacerations. Both groups demonstrated 100% anatomical and functional success at one-month follow-up, with only minor, transient postoperative symptoms. These findings suggest that silicone sling remnants are an equally effective, low-cost alternative to commercially available stents, especially in resource-limited settings. Demographics and Etiology

Our patient population was predominantly young males, with a mean age of 29.6 years, and road traffic accidents (RTAs) were the most common etiology (67%). This pattern is consistent with other Indian and Asian studies, where RTAs are the leading cause of ocular adnexal trauma due to increased two-wheeler use and lack of protective gear [3,4]. In contrast, Western literature often cites sports injuries and dog bites as frequent causes [1,8]. The male predominance seen in our study aligns with the general trauma epidemiology, where men are more likely to engage in high-risk outdoor activities [2]. Pediatric cases, although fewer, highlight the importance of prompt repair to prevent long-term sequelae such as amblyopia [11].

Anatomical and Functional Outcomes
In our study, all patients achieved anatomical success, defined as canalicular patency on irrigation post stent removal. Functionally, none reported persistent epiphora, indicating successful tear drainage. These results mirror those of Naik and Ali [4], who demonstrated excellent outcomes with Minimonoka stents, and Singh et al. [3], who reported similar success using indigenous silicone alternatives. The comparable performance of both groups reinforces the feasibility of low-cost substitutes without compromising clinical outcomes.

Comparison with Literature
Several studies have assessed outcomes following canalicular repair using different stents. Ali [2] highlighted the growing role of monocanalicular stents in lacrimal drainage surgery, citing reduced trauma and easier placement compared with bicanalicular systems. Tavakoli et al. [8] reported favorable results with a novel monocanalicular silicone tube, echoing our findings of low complication rates.

In India, Singh et al. [3] and Kumar et al. [5] demonstrated that indigenous stents such as silicone rods or cannulae achieve outcomes comparable to imported devices. Similarly, Guo et al. [9] and Li et al. [10] in China found high success rates with both commercial and modified stents, particularly when surgery was performed promptly. The present study adds prospective data supporting the efficacy of silicone sling remnants, further validating earlier

retrospective findings.

Complications and Safety

The most common postoperative complaint in both groups was transient irritation, resolving within one week. No cases of stent extrusion, granuloma formation, or canalicular obstruction were observed. Comparable complication profiles have been reported in other studies using monocanalicular stents [6,12]. The absence of serious complications in our cohort underscores the safety of both Minimonoka and silicone sling techniques when performed by experienced surgeons.

Cost-effectiveness and Accessibility

One of the most important implications of this study lies in the economic domain. Minimonoka stents, though effective, are relatively expensive and not always available in smaller centers in India. Conversely, silicone sling material is inexpensive, widely available, and already familiar to ophthalmic surgeons for ptosis and strabismus procedures. By repurposing this readily accessible material, surgeons can offer effective canalicular repair without incurring high costs. This is particularly relevant in government hospitals and rural settings, where patients often cannot afford imported implants [7].

The broader public health benefit of validating indigenous alternatives is significant.

Trauma-related epiphora affects predominantly young, working-age individuals, and restoring function cost-effectively reduces both direct treatment costs and indirect economic losses due to reduced productivity.

Pediatric and Revision Cases

Although the number of pediatric cases in our series was small, outcomes were favorable. Previous literature has suggested that canalicular repair in children may be more challenging due to smaller anatomy and higher risk of stent extrusion[11]. However, our findings align with Zhao et al. [11], who showed good long-term patency in pediatric repairs when performed early and with careful technique.

Revision cases were not encountered in our series; however, Kim et al. [12] reported good success rates using Minimonoka stents in both primary and revisional canalicular repairs. Silicone sling remnants may offer similar benefits, though larger studies are required to assess their role in complex or repeat surgeries.

5. Strengths and Limitations

The strengths of this study include its prospective design, use of a comparative cohort, and consistent surgical technique performed by experienced oculoplastic surgeons. The inclusion of both commercial and indigenous materials allows for meaningful evaluation of cost-effective alternatives in real-world practice.

However, the study has several limitations. The sample size (24 patients) was relatively small, limiting the statistical power to detect subtle differences between groups. The follow-up period (1 month after stent removal), while sufficient to confirm short-term success, does not provide information on long-term outcomes such as delayed stenosis or recurrence of epiphora.

Additionally, the study was non-randomized, which may have introduced selection bias.

Future studies with larger, randomized cohorts and longer follow-up are necessary to confirm the durability of outcomes and to establish standardized protocols for preparing and inserting silicone sling remnants. Comparative cost-analysis studies would also be valuable to formally quantify the economic advantages of indigenous materials.

6. Clinical Implications

The findings of this study support the adoption of silicone sling remnants as a reliable alternative to Minimonoka stents in routine clinical practice. For ophthalmologists in developing countries, this technique offers a practical, affordable, and effective solution that ensures patients receive timely and successful canalicular repair, regardless of financial constraints. Furthermore, training programs in oculoplastic surgery should incorporate indigenous alternatives to prepare surgeons for diverse clinical settings.

In summary, our study demonstrates that silicone sling remnants are as effective as Minimonoka stents in achieving anatomical and functional success following monocanalicular repair. Given their low cost, accessibility, and safety profile, silicone slings represent a valuable option for surgeons practicing in resource-limited environments. These findings contribute to the growing body of evidence supporting innovative, cost-effective strategies in ophthalmic trauma management.

7. Conclusion

Monocanalicular intubation with silicone sling remnants is an effective, safe, and economical alternative to Minimonoka stents in the repair of traumatic canalicular lacerations. This technique is especially valuable in resource-limited settings without compromising anatomical or functional success.

Conflicts of Interest: The authors declare that they have no competing interests.

Financial Support and Sponsorship: Nil.

Ethics Statement

This study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from the Institutional Ethics Committee of Datta Meghe Medical College, Nagpur, Maharashtra, India. Written informed consent was obtained from all participants (or their guardians in case of minors) prior to inclusion in the study.

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