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Assessment of Post-Surgical Outcomes of Triangular, Envelope, and Modified Triangular Flap Designs in the Extraction of Impacted Mandibular Wisdom Teeth

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ABSTRACT: ***Background:*** The surgical extraction of impacted mandibular third molars remain a standard procedure in oral and maxillofacial surgery. The choice of flap design significantly influences the postoperative outcomes, including pain, swelling, and mouth opening (trismus). The triangular flap, modified triangular flap, and envelope flap each present distinct advantages and limitations, necessitating comparative evaluation to identify the most effective technique. ***Methods:*** A randomized controlled comparative study involved 45 healthy participants aged 20-30 who underwent surgical removal of impacted mandibular third molars. Participants were randomly assigned to three groups (n=15 each): Envelope Flap, Triangular Flap, and Modified Triangular Flap. Preoperative and postoperative assessments were conducted, measuring pain and swelling via visual analog scales (VAS) and trismus by interincisal mouth opening in millimeters. Data were collected on postoperative days 1, 3, 7, and 10. Statistical analyses included Fisher's exact test for qualitative variables (pain and swelling) and unpaired t-tests for quantitative variables (mouth opening). ***Results:*** Significant clinical differences were observed among flap designs. On Day 1, severe pain was notably higher in the Envelope Flap group (60%) compared to Triangular (27%) and Modified Triangular Flaps (40%) ($p<0.05$). Similarly, severe swelling was most prevalent in the Envelope Flap group (47%), significantly more than the Triangular (13%) and Modified Triangular (40%) groups ($p<0.05$). The Triangular Flap demonstrated the quickest recovery for both pain and swelling by Day 7. Mouth opening recovery was significantly better in the Triangular Flap group, with 27% achieving near-normal mouth opening by Day 10 compared to none in the other groups ($p<0.05$). ***Conclusion:*** Among the three flap designs studied, the Triangular Flap exhibited superior postoperative outcomes, validated by robust statistical significance ($p < 0.05$), resulting in reduced pain and swelling and quicker functional recovery of mouth opening. The Modified Triangular Flap provided intermediate results, suggesting its potential as an effective alternative.

Keywords: Flap design, Impacted, Incision.

Article at a glance:

***Study Purpose*:** *To compare triangular, modified triangular, and envelope flap designs and their postoperative outcome in the surgical removal of impacted mandibular third molar.*

Key findings: *The Triangular Flap design was associated with the most favorable postoperative outcomes.*

Newer findings: *Triangular Flap group achieved the most robust recovery, with 27% regaining preoperative mouth opening levels (55–50 mm), unmatched by the Envelop (0%) and Modified Triangular (0%) groups ($p = 0.01$).*

INTRODUCTION

The surgical removal of impacted mandibular third molars remain one of the most common procedures in oral and maxillofacial surgery, and surgical techniques heavily influence postoperative outcomes. Among technical considerations, flap design is pivotal, as it directly affects intraoperative visibility, tissue trauma, and subsequent healing processes.[1] Various flap designs have been proposed, and clinicians continue to debate the optimal approach for minimizing complications such as pain, swelling, trismus, and delayed wound healing. Current evidence suggests traditional flap designs, like triangular and Envelope flaps, have inherent advantages and limitations.[2] The triangular flap, characterized by a vertical releasing incision, provides excellent surgical access but may increase soft tissue trauma.[3] Conversely, the envelope flap preserves

tissue integrity through a longer sulcular incision but can offer limited visibility in complex impactions.[4] This dilemma has led to modified approaches, such as the modified triangular flap, which attempts to balance access requirements with tissue preservation via an altered incision geometry.[5]

The choice of flap not only influences immediate postoperative recovery but can also affect long-term periodontal health and patient satisfaction. Improper flap design may lead to gingival recession or periodontal defects on the second molar and increase the risk of complications like alveolar osteitis.[6] Moreover, tension-free repositioning of the mucoperiosteal flap is critical to prevent hematoma formation and to ensure primary intention healing.[7] These considerations underscore the need for evidence-based guidelines when selecting a flap design. This study addresses gaps in the literature by systematically comparing three flap designs—triangular, modified triangular, and Envelope—in terms of patient-centered outcomes. Using quantitative measures of pain (VAS), swelling, and mouth opening with a standardized surgical protocol in a randomized controlled design, the study provides insight into the relative merits of each flap technique.[8] The findings are intended to inform clinical decision-making and optimize third-molar surgery outcomes.[9] This study aimed to compare the postoperative outcomes, specifically pain, swelling, and trismus, associated with three different mucoperiosteal flap designs (triangular, modified triangular, and Envelope) in the surgical extraction of impacted mandibular third molars.

MATERIALS AND METHODS

This randomized controlled trial included 45 patients between 20 and 30 years of age who were presented to the Department of Oral and Maxillofacial Surgery at Rajshahi Medical College. After explaining the procedure, informed consent was obtained from each participant. All patients were systemically healthy, with no medications that could affect healing, nonsmokers, and had healthy oral soft tissues. Patients meeting these criteria were randomly allocated into three equal groups of 15, each corresponding to one of the flap designs. Group I underwent extraction with a triangular flap, Group II with an envelope flap, and Group III with a modified triangular flap. A thorough history was recorded, and baseline measurements were taken: pain and swelling were self-assessed by patients using a visual analog scale (VAS), and maximum mouth opening was measured (in millimeters) as the distance between the upper and lower central incisor edges.[10] All surgeries were performed under local anesthesia (2% lidocaine with 1:200,000 epinephrine) via inferior alveolar, lingual, and long buccal nerve blocks.[11] For the envelope flap, a sulcular incision was made from the mandibular first molar to the second molar, followed by a distal extension along the mandibular ramus (Figure 1).[12] For the triangular flap, the incision was made from the mandibular ramus to the distobuccal aspect of the second molar, then a perpendicular releasing incision (~10 mm long) was extended into the buccal vestibule (Figure 2).[12] The modified triangular flap featured an incision that extended along the mucogingival junction, with minimal reflection of the second molar's periodontal tissues on the facial side (Figure 3).[12]

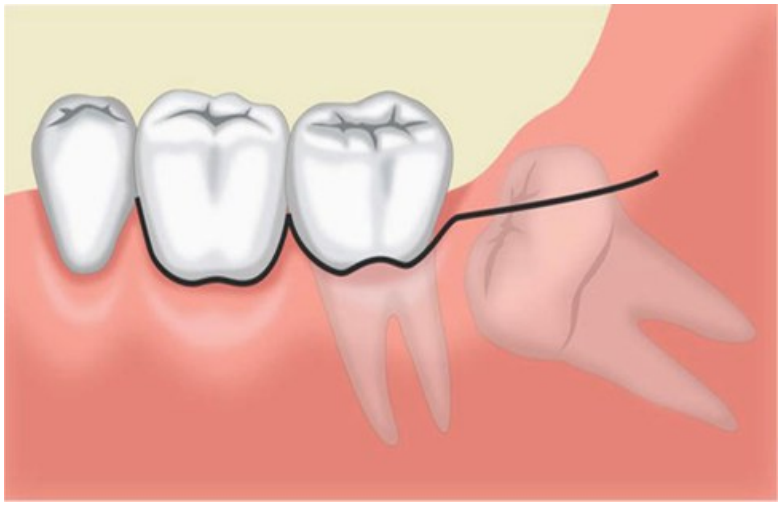

Figure 1: Illustration of the envelope flap incision (black line) extending from the distal of the second molar and along the mandibular ramus. This design involves a long sulcular incision without a vertical release, preserving gingival tissue but potentially limiting surgical access.

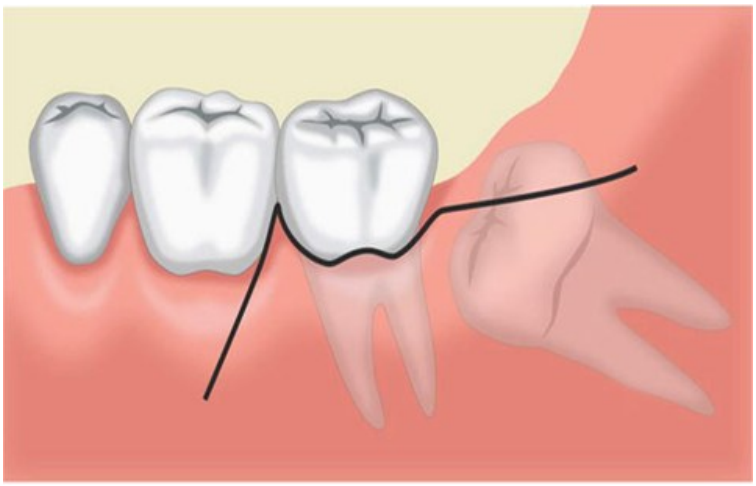

Figure 2: Illustration of the triangular flap incision (black line). The incision runs from the mandibular ramus to the distal side of the second molar, with a short vertical releasing incision into the buccal vestibule. This design provides excellent access to the surgical site at the expense of a slightly larger wound.

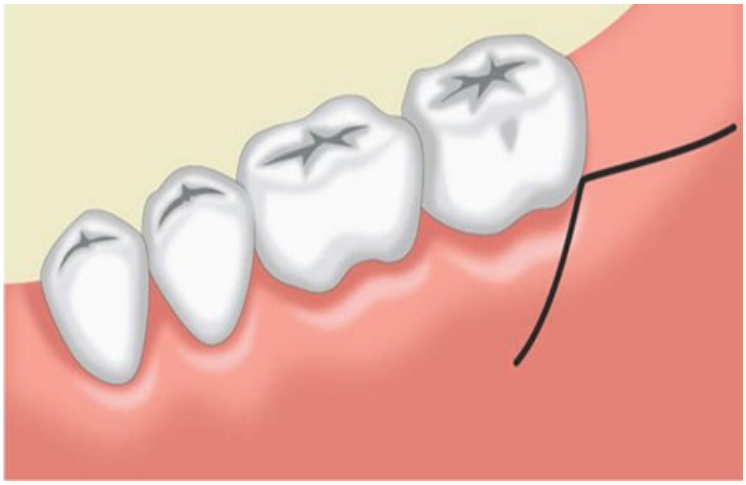

Figure 3: Illustration of the modified triangular flap incision (black line). The incision extends along the mucogingival junction near the second molar with a small relieving component. This approach aims to balance surgical access and tissue preservation.

Bone removal was done with a rotary bur under copious sterile saline irrigation for tooth elevation. In all cases, flap closure was achieved with interrupted sutures: the envelope flap required suturing at the distal end only, whereas the triangular and modified triangular flaps included a suture to secure the vertical incision.[13] Care was taken to reposition the flap without tension at the second molar region; a slightly loose approximation at the apical end of the vertical incision was allowed to enable drainage of any hematoma. All patients received postoperative medications consisting of oral antibiotics (Cefixime 500 mg twice daily and Metronidazole 400 mg three times daily for 5 days) and an NSAID (Etoricoxib 120 mg once daily for 3 days) for pain control.[14] Standard postoperative instructions were given in writing, and patients were advised to maintain gentle oral hygiene. Sutures were removed on the seventh postoperative day. Pain and facial swelling were evaluated on postoperative days 1, 3, 7, and 10 using VAS scores, which were categorized for analysis (none, mild, moderate, severe). Trismus was assessed by measuring maximum mouth opening (mm) on days 3, 7, and 10. For data analysis, continuous variables (e.g., mouth opening in millimeters) are presented as mean ±

standard deviation (range), and categorical variables (pain and swelling grades) as frequencies and percentages. Statistical significance was set at $p < 0.05$ (95% confidence interval). Intergroup comparisons for quantitative outcomes were performed with unpaired t-tests, while qualitative outcomes were compared using Fisher's exact test.

RESULTS

Forty-five impacted third molar surgeries were evaluated, comparing the three flap techniques (Envelope, Triangular, Modified triangular). Postoperative pain, swelling, and mouth-opening (trismus) outcomes were recorded and analyzed over the 10-day follow-up period.

Pain

Clear differences in pain were observed among the groups. Preoperatively, all patients were pain-free. By postoperative Day 1, 9 of 15 patients (60%) in the Envelope flap group reported severe pain, a significantly higher proportion than in the Triangular flap group (4 of 15; 27%, p = 0.008) and the Modified triangular flap group (6 of 15; 40%, p = 0.012). This suggests that the envelope incision may introduce more significant initial tissue trauma, leading to more intense early pain. By Day 3, the Triangular flap group showed a faster reduction in pain: cases of moderate pain in this group dropped from 67% on Day 1 to just 13% on Day 3 (p = 0.03). By Day 10, the pain had nearly resolved in the Triangular flap group (93% of patients reported no pain), outperforming both the Envelope flap group (60% pain-free) and the Modified triangular flap group (67% pain-free) (p = 0.02) in terms of complete pain resolution. In summary, the Triangular flap provided the most rapid alleviation of postoperative pain (Figure 4).

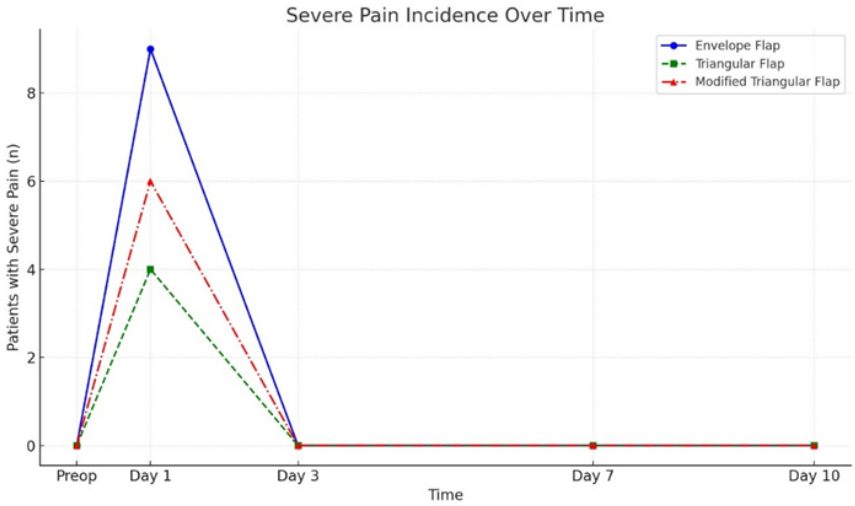

Figure 4: Graphical comparison of the incidence of severe postoperative pain over time among the three flap groups. The Envelope flap group had the most significant number of patients with severe pain on Day 1, followed by the Modified triangular flap group, whereas the Triangular flap group had the fewest. In all groups, the incidence of severe pain dropped to zero on Day 7.

Swelling

The pattern of facial swelling paralleled the pain findings. On Day 1, 7 of 15 patients (47%) in the Envelope flap group experienced severe swelling, compared to 2 patients (13%) in the Triangular flap group and six patients (40%) in the Modified triangular flap group (Envelope vs. Triangular, p = 0.01; Envelope vs. Modified, p = 0.02). The Triangular flap's design—allowing better drainage and a tension-free closure—likely contributed to the significantly lower initial swelling. By Day 7, the majority of the Triangular flap group (12 of 15, 80%) had no noticeable swelling, in stark contrast to the Envelope flap group (3 of 15, 20% no swelling) and the Modified triangular group (6 of 15, 40% no swelling) (p = 0.04 for Triangular vs. Envelope). Even on Day 10, the Triangular flap group maintained an advantage, with 80% of patients free of swelling, whereas the Modified triangular flap group improved to 60% and the Envelope flap to 47%. The difference between the Modified triangular and Envelope groups on Day 10 was significant (p = 0.03), underscoring the persistent

disadvantage of the envelope flap regarding swelling resolution (Figure 5).

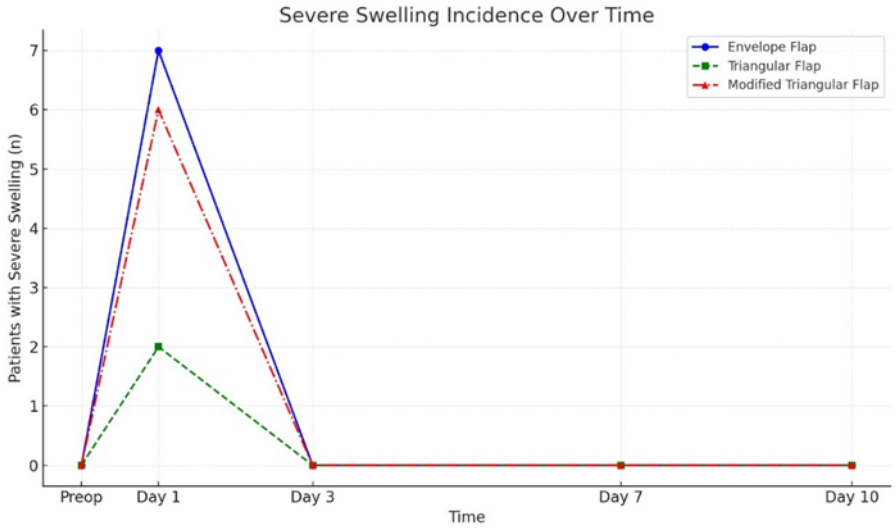

Figure 5: Postoperative severe swelling incidence over time for each flap design. The Envelope flap resulted in the highest number of patients with severe swellings on Day 1, whereas the Triangular flap had the fewest. By Day 3, severe swelling had subsided in all groups.

Mouth Opening (Trismus)

Postoperative jaw mobility also differed between groups. All patients had a baseline mouth opening of approximately 50–55 mm. On Day 1, marked trismus (severe limitation of mouth opening to ~30–34 mm) was observed in 7 patients (47%) in both the Envelope and Modified triangular flap groups. In contrast, only three patients (20%) in the Triangular flap group had such severe limitations ($p = 0.02$ when comparing Triangular vs. Envelope). By Day 3, mouth opening in the Triangular flap group improved significantly (most patients could open beyond 34 mm), whereas considerable restrictions persisted in the other two groups. By Day 10, the Triangular flap group demonstrated complete functional recovery: 4 out of 15 patients (27%) regained their preoperative range of mouth opening (~50–55 mm). None of the patients in the Envelope or Modified triangular groups achieved a return to baseline opening by Day 10 ($p = 0.01$) (Figure 6).

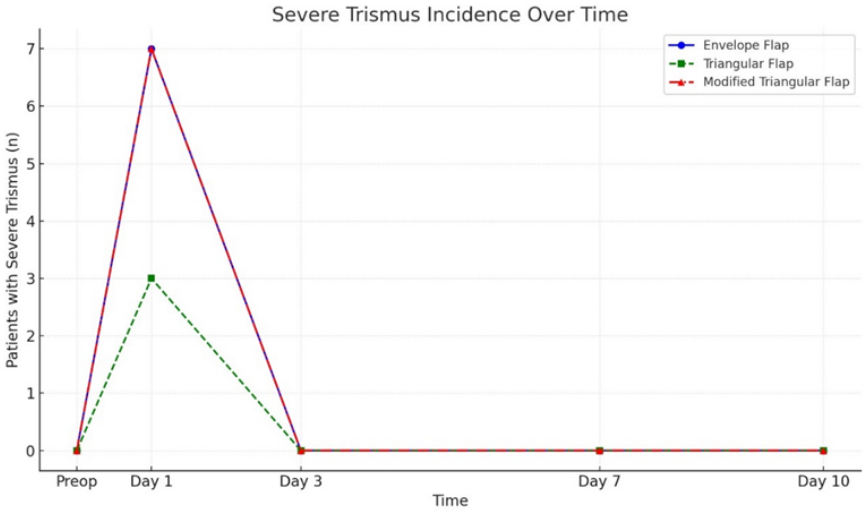

Figure 6: Postoperative severe trismus (limited mouth opening) incidence over time. On Day 1, the Envelope and Modified triangular flaps caused severe trismus in nearly half of patients, whereas the Triangular flap group was less affected. All groups showed resolution of severe trismus by Day 7.

Table 1 summarizes key postoperative outcomes for each flap design. Overall, the Triangular flap demonstrated statistically significant advantages in reducing early postoperative pain and swelling and promoting faster recovery of jaw function compared to the Enveloped and Modified triangular flaps.

Table 1: Summary of Postoperative Outcomes by Flap Design

Outcome	Envelope Flap	Triangular Flap	Modified Triangular Flap	p-value
Pain – Day 1: Severe Pain (%)	60%	27%	40%	0.008 (Envelope vs Triangular)
Pain – Day 10: Pain-Free (%)	60%	93%	67%	0.02 (Triangular vs others)
Swelling – Day 1: Severe Swelling (%)	47%	13%	40%	0.01 (Envelope vs Triangular)
Swelling – Day 10: No Swelling (%)	47%	80%	60%	0.03 (Modified vs Envelope)
Mouth Opening – Day 10: Full Recovery (%)	0%	27%	0%	0.01 (Triangular vs others)

DISCUSSION

Flap design plays a critical role in the surgical removal of impacted mandibular third molars, influencing both immediate postoperative outcomes and long-term healing. This study compared triangular, modified triangular, and envelope flaps to evaluate their impact on pain, swelling, trismus, and overall recovery. Our results indicated that the Triangular flap offered the most favorable outcomes among the three designs. The Triangular flap group experienced significantly lower pain levels and faster resolution than the Envelope flap group. This can be attributed to the improved surgical access provided by the vertical releasing incision, which may reduce the duration of tissue manipulation and trauma. While one might expect the Modified triangular flap to minimize pain by limiting tissue reflection, our findings yielded intermediate pain outcomes—better than the Envelope flap but not as good as the Triangular flap.[15] This contrasts with some reports where modified triangular flaps were associated with superior pain control.[16]

Postoperative swelling was likewise lowest in the Triangular flap group. The combination of adequate access and tension-free flap repositioning likely allowed for effective drainage and minimal edema. Envelope flaps, although preserving more tissue, appeared to trap inflammatory exudate, resulting in more significant swelling. Modified triangular flaps showed moderate swelling, supporting that a shorter flap with a small releasing incision can reduce (but not eliminate) postoperative edema. Our observations differ from studies that found minimal swelling with modified flaps, suggesting that surgical technique and patient factors can influence outcomes.[17] Trismus, or limited mouth opening, was most pronounced initially in the Envelope and Modified triangular flap groups, presumably due to more significant retraction of the triangular soft tissues (including buccinator muscle) during those flap reflections. The Triangular flap, in contrast, allowed many patients to maintain better mouth opening in the early postoperative period.[18]. By Day 10, a subset of patients in the Triangular flap group had regained near-normal jaw function, which none in the other groups achieved. This supports the notion that flap designs avoid excessive soft tissue and muscle involvement and facilitate a quicker return to function.[19]

From a clinical perspective, these findings underscore the importance of selecting an appropriate flap design based on the surgical situation.[20] Traditional triangular flaps offer excellent visibility and access during third molar surgery, which our study translated to better postoperative recovery (despite concerns about a larger incision).[21] Envelope flaps, while conserving soft tissue and often preferred for simpler cases, may be associated with more incredible early pain and swelling under challenging impactions.[22] The Modified triangular flap is a compromise approach, providing reasonably good access with potentially less trauma than a full triangular flap. Our results, however, indicate that the

Triangular flap might still be the best choice for minimizing patient morbidity in cases of high surgical difficulty.[23] It should be noted that patient-reported satisfaction was not formally measured in this study. Nonetheless, given the differences observed in pain and functional recovery, it can be inferred that patients in the Triangular flap group would be most satisfied due to quicker relief of symptoms. Further research with larger sample sizes, including quality-of-life metrics and evaluation of long-term outcomes (such as periodontal healing and incidence of complications like dry socket), would be valuable to validate and expand upon these findings.

CONCLUSION

The Triangular flap emerged as the most effective design for impacted mandibular third molar surgery in this comparative study. It was associated with significantly lower postoperative pain and swelling and a faster recovery of mouth opening compared to both the Envelope and Modified triangular flaps. While the Envelope flap is less invasive initially, it tended to result in higher early morbidity, and the Modified triangular flap offered only intermediate benefits. These findings suggest that the Triangular flap may be the preferred choice when rapid recovery and patient comfort are priorities—especially in complex impactions requiring extensive access. Flap design should thus be considered not merely a technical detail but a key determinant of surgical success. Surgeons should select the flap design best suited to the patient's needs and the surgical complexity, guided by evidence-based insights such as those in this study.

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Authors' Contributions

S.A. conceptualized the study, designed the methodology, performed data analysis and interpretation, drafted the manuscript, and supervised the research. S.A., A.F.M.S.R., M.S.H.S., M.H.H., and M.A.H. contributed to data collection and statistical analysis. All authors reviewed and approved the final manuscript.

Declarations

Ethical Approval: All participants provided informed consent, and relevant ethical guidelines and regulations conducted the study.

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Conflict of Interest: The authors declare no conflict of interest.

Consent for Publication: Obtained from all participants.

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