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# Tranexamic Application on Open Procedure of Shoulder: Systematic Review and Meta-Analysis of Randomized Study

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## ABSTRACT

**Background:** Open shoulder procedures are frequently associated with significant intraoperative blood loss and postoperative hemarthrosis, which may impair surgical visualization, increase transfusion needs, and delay recovery. Tranexamic acid (TXA) has demonstrated efficacy in reducing perioperative bleeding in major orthopedic surgeries, especially hip and knee arthroplasty, but open shoulder surgery data is lacking. This research examines the effects of TXA in open shoulder surgery using recent studies.

**Materials and Methods:** A comprehensive review and meta-analysis of randomized controlled trials compared TXA vs non-TXA results. A systematic search of PubMed, MEDLINE, EMBASE, and CENTRAL found relevant papers.

**Results:** TXA substantially decreased postoperative drain output compared to placebo (MD –61.31 mL, 95% CI –93.00 to –28.72; p = 0.0002). Compared to placebo, TXA substantially decreased perioperative hemoglobin decline (MD –0.90, 95% CI –1.35 to –0.44; p = 0.0001) and considerably reduced postoperative hematoma risk (OR 0.21, 95% CI 0.09 to 0.45; p < 0.0001). Although TXA reduced total blood loss, operational time, and postoperative VAS, these changes were not statistically significant.

**Conclusion:** TXA reduces intraoperative blood loss during shoulder surgery without serious consequences

***Keywords:*** randomized controlled trials, shoulder surgery, tranexamic acid

## INTRODUCTION

Open shoulder procedures are frequently associated with significant intraoperative blood loss and postoperative hemarthrosis, which may impair surgical visualization, increase transfusion needs, and delay recovery. Effective perioperative blood loss management is a critical aspect of shoulder surgery.[1] With the rapid increase in both shoulder arthroplasty and arthroscopic procedures in recent years, minimizing intraoperative and postoperative bleeding, as well as reducing the need for transfusions, has become a major clinical focus. Numerous studies have demonstrated positive outcomes from strategies aimed at controlling blood loss.[2]

Tranexamic acid (TXA) prevents fibrin breakdown by reducing plasminogen-to-plasmin conversion. It reduces blood loss, soothes postoperative discomfort, and improves range of motion.3 TXA has been shown to minimize perioperative

hemorrhage and enhance hip and knee arthroplasty recovery. Multiple meta-analyses have shown that it reduces blood loss during lower limb joint replacement without increasing thromboembolic consequences.[4]

Increasing data supports TXA in open and arthroscopic shoulder operations. Systematic reviews and meta-analyses show it improves perioperative hemostasis. However, additional RCTs have appeared, necessitating an updated meta-analysis to integrate the latest data and guide clinical decision-making regarding TXA administration in shoulder surgery.[5]

Unlike surgeries involving joints where a tourniquet can be applied, managing blood loss during shoulder operations poses greater challenges. Consequently, various methods to minimize intraoperative bleeding have been actively investigated. Over recent decades, TXA has gained widespread application in orthopedic procedures, consistently demonstrating beneficial effects on blood conservation and patient recovery.[6]

TXA's effects on total blood loss and drain output in adult shoulder surgery patients were the focus of this meta-analysis. Secondary outcomes were VAS postoperative discomfort, surgery time, hemoglobin alterations, and hematoma.

## MATERIALS & METHODS

### Search Strategy

The study followed PRISMA guidelines. A comprehensive search was undertaken from 2020 to 2024 for research for this study. Pubmed, Cochrane, Wiley Online databases are utilized. Researchers employing "tranexamic acid", "shoulder surgery", and "randomized controlled trials". The reference lists and abstracts were reviewed individually. Reviewer disagreements over include research will be resolved by consensus and, if required, outside review. This study will compare all tranexamic applications on open shoulder surgery in English and use entire text. A meta-analysis examines the main and secondary effects of tranexamic on open shoulder surgery.

### Inclusion Criteria

The criteria for incorporating studies were: (1) RCT studies that evaluate the effect of tranexamic application (intravenous or local) on open shoulder surgery; (2) English language studies; (3) 2020–2024 studies that compared the latest and greatest tranexamic application; and (4) studies that report outcomes measurements like total blood loss, drain output, postoperative pain, and operation length, hemoglobin changes, presence of hematoma. Excluded from consideration were studies including individuals who had arthroscopic shoulder surgery, using other antifibrinolytic agents, or not reporting relevant outcomes (Table 1).

**Table 1. PICO Criteria for Inclusion Study**

| | Inclusion | Exclusion |
|---|---|---|
| Patient | Adult patients (≥18 years old) undergoing open shoulder surgery, including open shoulder arthroplasty, open rotator cuff repair, or open stabilization procedures | Patients undergoing arthroscopic shoulder surgery, pediatric patients (<18 years old), or those with underlying coagulopathy or infection |
| Intervention | Administration of TXA via any route (intravenous, topical, or intra-articular) during the perioperative period. | Studies using other antifibrinolytic agents (e.g., aminocaproic acid) without TXA, or combination therapies not isolating TXA's effect |
| Control | Placebo or no TXA administration (standard care) | Studies without a control group or comparing TXA with active non-equivalent drugs |
| Outcome | At least one of the following outcomes reported: total blood loss, drain output, postoperative pain, length of operation, hemoglobin changes, presence of hematoma | Studies not reporting relevant outcomes related to bleeding, transfusion, or complications |
| Design | Randomized controlled trials (RCTs) with full-text available in English and sufficient quantitative data for extraction | Non-randomized studies, observational studies, case reports, case series, conference abstracts, reviews, or meta-analyses |

### Quality Evaluation

Reviewers were neutral and examined every paper. Disagreements were resolved by discussion and consensus. The same independent reviewers will examine the included papers using the seven Cochrane criteria for evaluating risk of bias in the "Risk of bias" evaluation tool: selection, performance, detection, attrition, reporting, and other bias (Figure 1 and Figure 2).

### Data Synthesis

Data extraction was done utilizing tables under essential features and findings for every research discovered and included. After data collection, Review Manager performed quantitative analysis. Results were shown on forest plots. In each research, the mean difference for continuous outcome and odds ratio for dichotomous outcome with 95% CI were estimated. When I2 was less than 10%, a fixed-effects model was used; when it was more, a random-effects model was used.

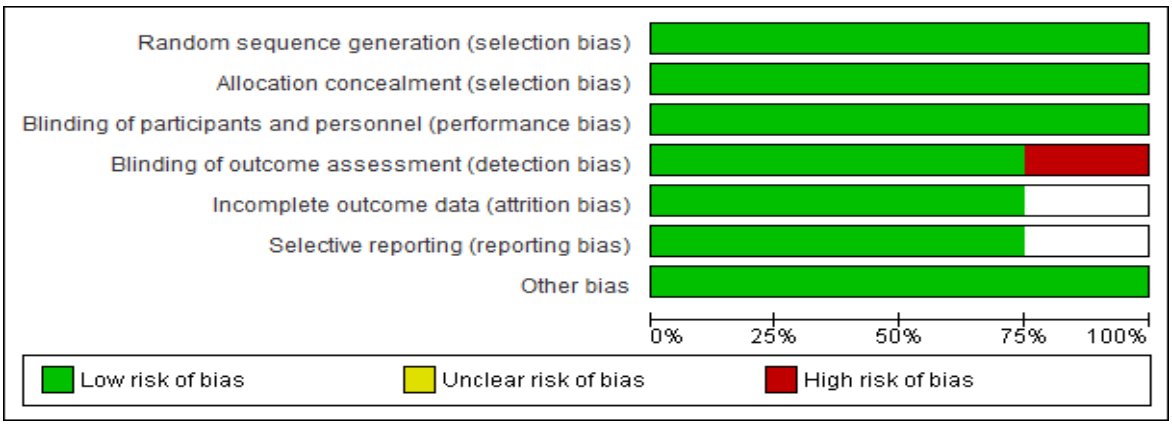


**Figure 1. Risk of Bias Graph**

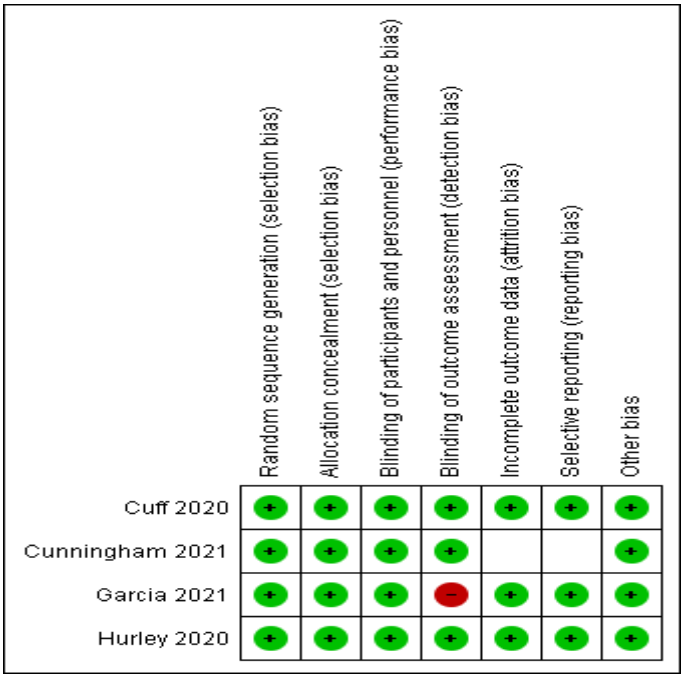


**Figure 2. Risk of Bias Summary**

## RESULT

### Literature search, study selection, and study characteristics

1742 records were found using the electronic search across several databases. Following the steps of removing duplicates,

screening, and excluding research, the final four studies were incorporated into the qualitative synthesis. The remaining papers were eliminated because they weren't in English, had different criteria, or didn't have enough statistical evidence. There were 306 patients in all in this meta-analysis, 157 of whom had TXA and 149 of whom had control treatment (Figure 3). The age range of the patient was 45–84 years old (Table 2).

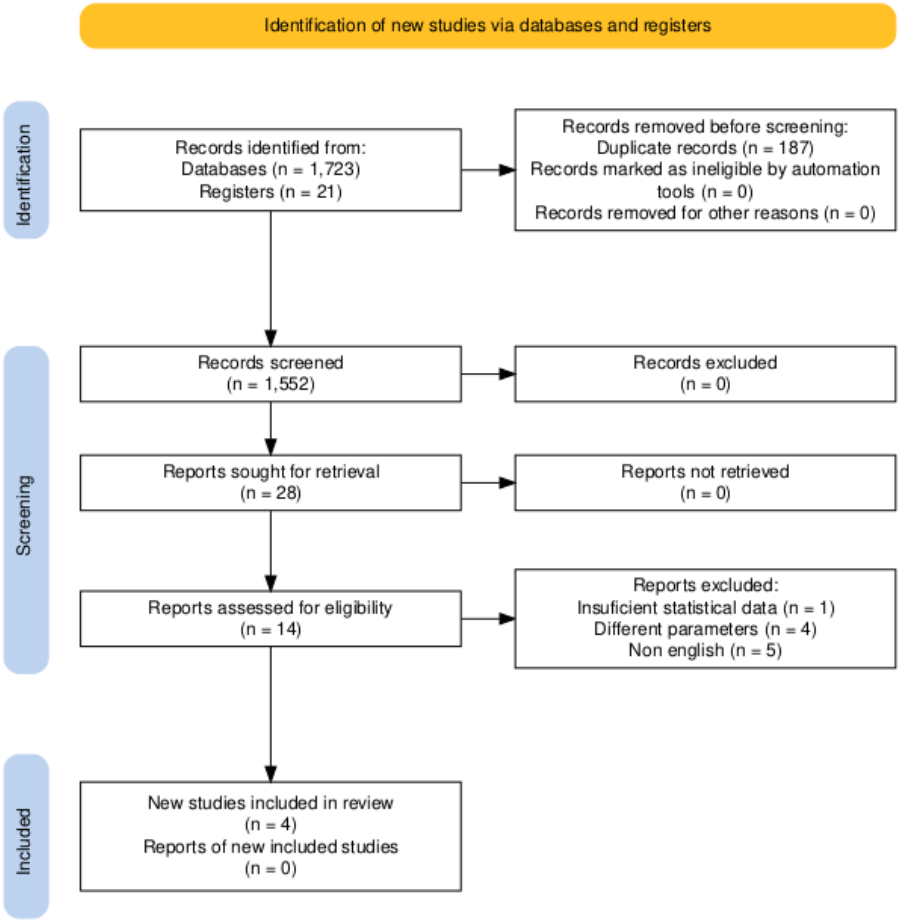


**Figure 3. PRISMA flowchart for the included study**

**Table 2. Main characteristics of the included studies (2020-2024)**

| No | Author (Year) | Country | Mode of administration | Administration method | Tx Dose | Placebo dose | Age | Male sex |
|---|---|---|---|---|---|---|---|---|
| 1 | Cuff et al (2020)[7] | USA | Intraarticular | Intraoperatively before skin incision | 1 g | 20 ml IV saline | 68 (45-84) vs 69 (49-82) | 20/53 vs 16/48 |
| 2 | Hurley et al (2020)[8] | Ireland | Intravenous | 15 min before skin incision | 1 g | 100 ml IV saline | 25.1 ± 6.5 vs 23.8 + 3.4 | 48/50 vs 48/50 |
| 3 | Cunningham et al (2021)[9] | Australia | Intravenous | Given before skin incision | 2 g | Saline solution | 72 ± 8 vs 73 + 9 | 11/31 vs 12/29 |
| 4 | Garcia et al (2021)[10] | Portugal | Intravenous | Immediately before surgery | 1 g | Saline solution | 76.7 ± 7.1 vs 75.7 + 5.7 | 4/23 vs 3/22 |

## Total Blood Loss

Total blood loss outcome analysis comprised 261 patients. Patients taking TXA showed no substantially lower total blood loss than the placebo group (MD: -70.84; 95% CI: -147.96 to 6.28; P = 0.07, I2 = 97%). Significant outcome heterogeneity was noted. Figure 4 summarizes results.

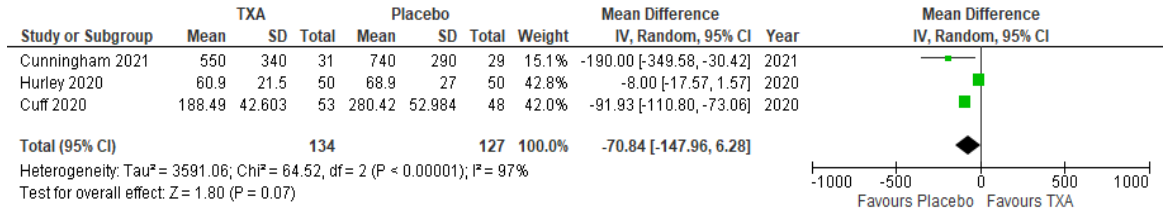


**Figure 4. Forest plot analysis of total blood loss**

## Drain Output

Patients in the TXA group had substantially lower drain output compared to the placebo group (MD: -61.31; 95% CI: -93.90 to -28.72; P = < 0.0002, I2 = 90%). Significant outcome heterogeneity was noted. Figure 5 summarizes results.

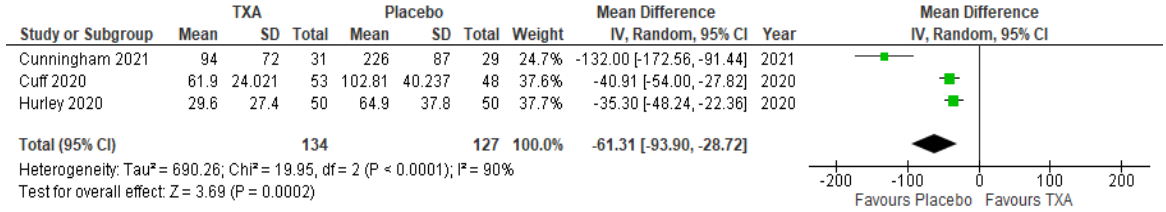


**Figure 5. Forest plot analysis of drain output**

## Postoperative VAS

Postoperative VAS pain score was analyzed in 160 individuals. Postoperative VAS pain scores were not substantially improved in the TXA group (MD: -0.70; 95% CI: -1.97 to -0.57; P = 0.28, I2 = 81%). Significant outcome heterogeneity was noted. Figure 6 summarizes results.

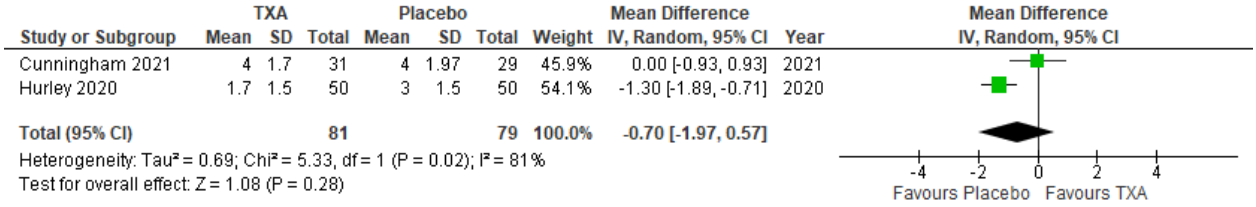


**Figure 6. Forest plot analysis of postoperative VAS**

## Length of operation

The pooled analysis showed no significant difference in operational time between TXA and placebo (Std MD: -0.24; 95% CI: -0.52 to 0.03; P = 0.08, I2 = 24%). Little heterogeneity was observed. Results are shown in Figure 7.

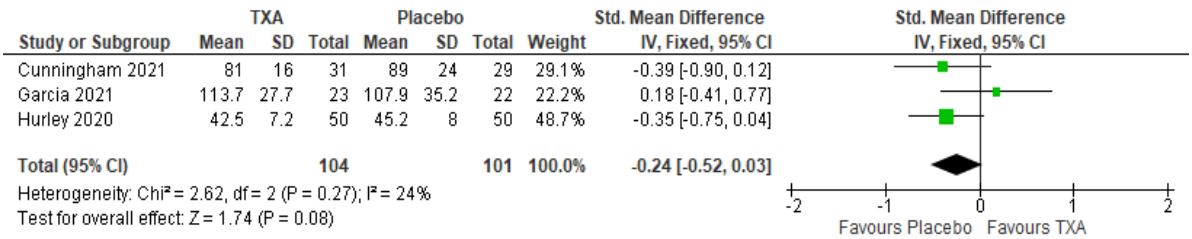


**Figure 7. Forest plot analysis of postoperative VAS**

## Hemoglobin changes

In the pooled analysis, TXA and placebo groups had significantly different hemoglobin decreases (MD: -0.90; 95% CI: -1.35 to -0.44; P = 0.0001, I2 = 66%).

Significant outcome heterogeneity was noted. Results are shown in Figure 8.

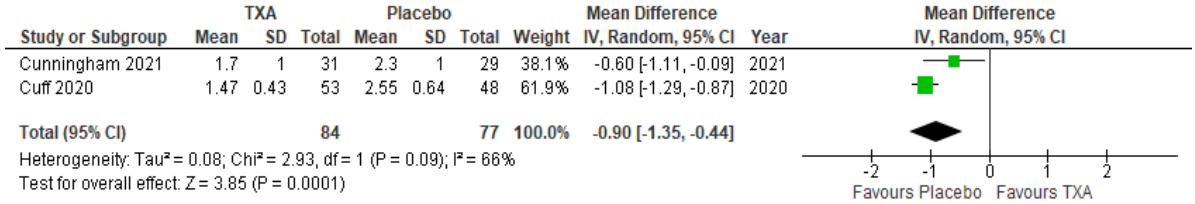


**Figure 8. Forest plot analysis of hemoglobin changes**

### Presence of Hematoma

The pooled analysis showed a significant difference in hematoma occurrence between TXA and placebo groups (OR: 0.21; 95% CI: 0.09 to 0.45; P < 0.0001, I2 = 37%). Little heterogeneity was observed. Figure 9 summarizes results.

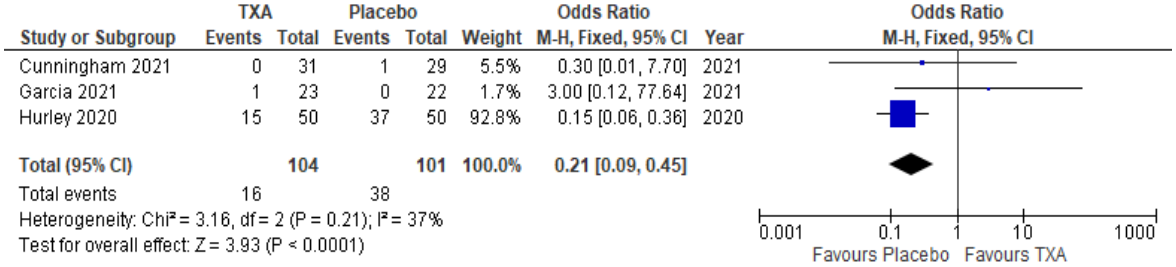


**Figure 9. Forest plot analysis of presence of hematoma**

## DISCUSSION

Our meta-analysis showed that TXA lowers perioperative blood loss, notably drain output, without increasing thromboembolic events. Similar benefits were shown in reducing perioperative hemoglobin and hematoma.

TXA, a synthetic antifibrinolytic, inhibits the plasminogen lysine-binding site reversibly and competitively. TXA blocks plasminogen-to-plasmin conversion, stabilizing the fibrin matrix and lowering fibrinolysis. In hereditary angioedema, TXA indirectly reduces complement activation by reducing plasmin activity, preserving C1 esterase inhibitors. Intravenous TXA is usually 1000 mg per 10 mL, whereas oral TXA is usually 650 mg tablets.[11]

The use of TXA in shoulder open procedure has gained popularity recently. Gillespie et al. found that intraoperative topical TXA decreased drain output and postoperative hemoglobin drop compared to normal saline in a prospective randomized experiment. Similar results were seen with intravenous injection.12 In another randomized controlled study, Vara et al. found that two intravenous doses of TXA (10 mg/kg each, 60 minutes before surgery and at wound closure) significantly reduced total blood loss, hemoglobin reduction, and drain output compared to a placebo. 14.3% of placebo patients needed postoperative transfusions, compared to 5.7% of TXA patients.13 Pauzenberger et al. found that two 1 g doses of TXA (one within 30 minutes after skin incision and one at wound closure) reduced blood loss, drain output, hematoma development, and pain ratings. No blood transfusions were needed in the TXA or placebo groups.[14]

The mechanism behind TXA's effect lies in its role as an antifibrinolytic. By preventing fibrin degradation, TXA stabilizes the formed clots and enhances hemostasis at the surgical site. This pharmacologic action effectively minimizes microvascular bleeding, reduces continuous oozing from capillaries, and prevents excessive consumption of clotting factors, which in turn helps preserve hemoglobin levels postoperatively.[15] As a result, patients

experience less perioperative anemia and recover faster without the complications associated with transfusions.

TXA plays a critical role in reducing hematoma formation, a common complication after open shoulder surgery that can cause pain, inflammation, and delayed wound healing. Hematomas often develop when fibrin clots are prematurely dissolved by plasmin activity, leading to the accumulation of blood in soft tissues. TXA maintains the stability of clots, thereby limiting subcutaneous or intra-articular bleeding. This stabilization not only reduces hematoma incidence but also contributes to less postoperative swelling and discomfort, facilitating improved joint mobility and rehabilitation.[16,17] Overall, TXA's ability to preserve fibrin integrity underlies its dual benefit of reducing blood loss and promoting a smoother postoperative recovery without elevating thromboembolic risks.

Most studies in our study had minimal bias across most rating categories, suggesting excellent methodological quality. We found substantial hemoglobin alterations, contrary to prior meta-analyses. These findings bolster the case for TXA in shoulder surgery. Our data show that TXA reduces blood loss and improves surgical outcomes, confirming its significance in perioperative care.

Note that this research has limitations. The included studies' inaccuracy and lack of uniformity in estimating total blood loss caused considerable variability in the findings. Additionally, TXA dose and timing varied, making it difficult to determine the best dosing procedure. Because trials reported different administration strategies, the best TXA delivery route could not be identified. Future study with defined methods should determine the best TXA dose, time, and route for shoulder surgery.

## CONCLUSION

The administration of TXA during shoulder surgery demonstrates both safety and efficacy in minimizing intraoperative blood loss. By stabilizing clot formation and reducing fibrinolysis, TXA effectively limits bleeding without increasing the risk of major complications such as thromboembolism. These findings support the routine consideration of TXA as an adjunctive measure in shoulder procedures to enhance surgical outcomes, improve visualization, and potentially reduce the need for transfusions. Further high-quality studies may help refine optimal dosing and administration protocols to maximize its clinical benefits.

### *Declaration by Authors*

**Ethical Approval**: Not applicable

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**Source of Funding:** None

**Conflict of Interest:** No conflicts of interest declared.

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