

BRIEF COMMUNICATION OPEN



# Accuracy and residual volume of intravitreal injection syringes in administration of very small volumes

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## INTRODUCTION

Intravitreal injections (IVIs) are widely used to deliver therapeutic agents for various retinal conditions. The syringe accuracy is a critical factor in achieving optimal treatment outcomes and minimizing potential risks in IVIs, such as unpredictable variation in drug volume (and thereby therapeutic effect) and intraocular pressure (IOP) rise [1–5]. Smaller volumes than the typical 0.05 mL, albeit harder to deliver with common 1-mL syringes, could mitigate the impact on IOP and drug wastage.

In this study, we evaluated the accuracy and residual volume of three syringe models that can potentially administer very small volumes intravitreally.

## MATERIALS AND METHODS

We investigated three syringe models (Fig. 1): BD Plastipak 1 mL luer slip (Becton Dickinson S.A., Madrid, Spain), Omnifix-F 1 mL (B. Braun Medical Inc., Melsungen, Germany), and Zero Residual Enhanced Dosing Technology (EDT) 0.2 mL (SJJ Solutions BV, Den Haag, Netherlands). Notably, the last model is designed to deliver very small volumes accurately. The BD Plastipak and the Omnifix-F were tested with a standard 30-gauge BD PrecisionGlide needle (Becton Dickinson S.A., Curitiba, Brazil), whereas the Zero Residual EDT was assembled with a 30-gauge Zero Residual needle (SJJ Solutions BV, Den Haag, Netherlands).

A trained member of the research team prepared and assessed each syringe-needle setup. Distilled water was used as the injection fluid, and volumes of 10, 20, 25, and 50  $\mu$ L were tested. The weight of the syringe-needle setup was measured before and after liquid aspiration and after ejection. The extra syringe-needle weight after liquid ejection defined the residual volume. Each simulation utilized a new syringe and needle. The weight was measured with an analytical balance (OHAUS Model PR224, Parsippany, NJ). The study was conducted at a stable 23 °C room temperature and 70% humidity.

## RESULTS

The Zero Residual EDT syringe demonstrated significantly lower volumes delivered and closer to the target volume across all tested volumes compared to the BD Plastipak syringe ( $p < 0.001$ ), as shown in Fig. 2A. In the comparison between the Zero Residual EDT and the B. Braun Omnifix-F syringe, significant differences were observed at volumes of 10 and 20  $\mu$ L. Furthermore, a statistically significant difference in residual volume was found between the three syringes for all volumes, with the Zero Residual EDT syringe exhibiting the lowest residual volume (Fig. 2B).

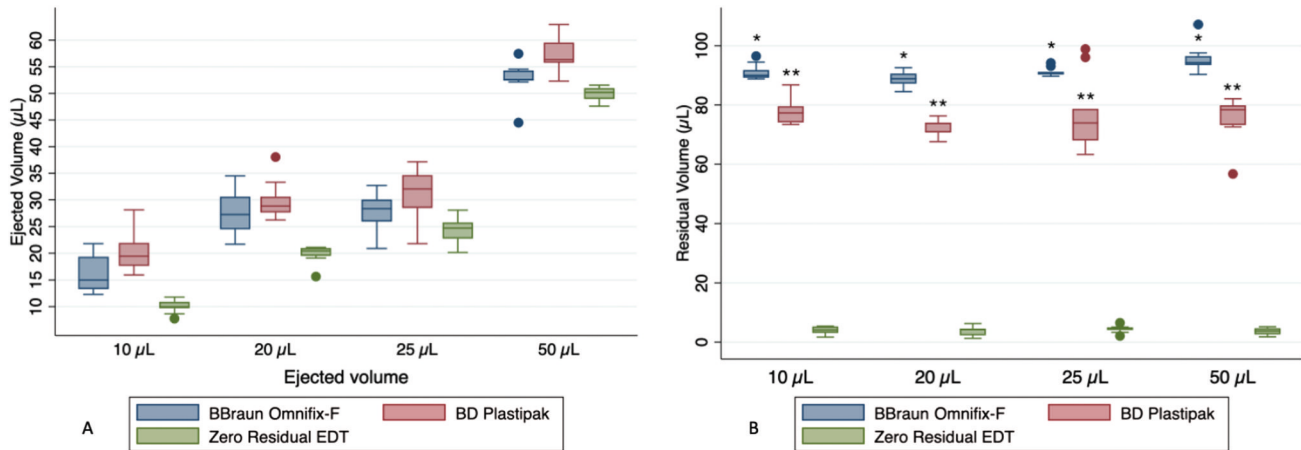
## DISCUSSION

The findings of this study highlight the importance of both syringe accuracy and residual volume in the setting of the very small volume delivered during IVIs. The Zero Residual EDT syringe performed better than the BD Plastipak and Omnifix-F syringes



**Fig. 1** The syringes tested in the study. Left: Omnifix-F from B. Braun Medical Inc. Middle: BD Plastipak from Becton Dickinson S.A. Right: Zero Residual EDT from SJJ Solutions BV.

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**Fig. 2 Accuracy and residual volume of the tested syringes.** **A** illustrates the variation for different ejection volumes (10, 20, 25, and 50  $\mu\text{L}$ ).  $*p < 0.001$  in comparison to Zero Residual EDT. **B** shows the residual volumes after ejection.  $*p < 0.001$  in comparison to both Zero Residual EDT and BD Plastipak;  $**p < 0.001$  in comparison to both Zero Residual EDT and Omnifix-F.

with regard to both accuracy and residual volume. The ability to accurately administrate very small volumes is a prerequisite for developing intraocular drugs with lower risk of increased IOP, which, for instance, has been associated with current pre-filled aflibercept syringes [4, 5]. Moreover, minimizing the residual volume of the syringe-needle setup can lead to considerable cost savings by reducing medicine waste. Further research and development in the field of syringe design for IVIs are warranted to explore the full potential of achieving accurate drug delivery, thereby optimizing the benefits and minimizing the risks of this standard ophthalmic procedure.

#### DATA AVAILABILITY

Additional data will be made available upon reasonable request.

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#### AUTHOR CONTRIBUTIONS

Conceived and designed the study: GBM, CM; analysed the data: GBM, CM, ØKJ, MCM; wrote the paper: GBM, critically revised the manuscript: GBM, LAS, LLMA, CM, ØKJ, and MCM; all authors read and approved the final manuscript.

#### COMPETING INTERESTS

GBM has been a consultant to Molecular Partners, Pine Pharmaceuticals, TriboFilm Research, and SJJ Solutions; and has been member of Bayer, Roche and West Pharmaceutical advisory boards. MCM is part of a collaborative agreement with SJJ Solutions for development of the Zero Residual Silicone Oil-free 0.2 mL syringe, has been a member of advisory boards at Bayer, Roche, Novartis, Allergan and Apellis and has received lecture fees from Bayer and Roche. ØKJ has applied patent for a glaucoma stent, is part of a collaborative agreement with SJJ Solutions for development of the Zero Residual Silicone Oil-free 0.2 mL syringe, has been member of Bayer, Roche, and Allergan advisory boards, and has received lecture fees from Bayer and Allergan. The other authors declare there are no competing interests in relation to this work.

#### ADDITIONAL INFORMATION

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