3D-Printable Micropipette

Martin D. Brennan[1], Fahad F. Bokhari[1], David T. Eddington[1,*],

1 Department of Bioengineering, University of Illinois at Chicago, Chicago, Illinois, USA

*** dte@uic.edu**

Abstract

This is the abstract.

Introduction

3D printing as a form of additive manufacturing has existed for decades although the recent availability of inexpensive desktop printers have made it feasible for consumers to design and print prototypes and even functional parts, and consumer goods [1]. The open source software movement and has spawned the additional areas of open source hardware, such as micro controller boards (Arduino) as well as 3D printers themselves (RepRap). Open source scientific instruments and laboratory equipment are being actively developed(openpcr.org, opensource lab book.) 3D-printable lab equipment is and an attractive idea because of the simplicity of downloading and printing a functional object for only the price of the raw material [2,3]. In addition, end users can customize the equipment to their application. Some of the more clever printable parts that have emerged are ones that give a new function to a ubiquitous existing device. For example a drill bit attachment was designed and printed to hold micro centrifuge tubes allowing a drill to be used for centrifuging samples. Although this may make a rather crude centrifuge it may be and adequate method that only costs pennies compared to commercially available centrifuges and could allow researchers in the developing world to better participate in science by reducing some financial barriers of entry. Printable micropipette designs can be found on 3D-part sharing websites (thingiverse). While existing designs may require only pen springs, a gasket made from a balloon, and tape, none allow adjustment to know volumes nor have any been rigorously validated. We present a pipette constructed from 3D printed parts that allows a 1 ml syringe to be actuated to an adjustable volume. The scale marks on the syringe can be used to adjust the dispensed volume accurately without calibrating with a scale.

Materials and Methods

Design

The device is designed to actuate a pipette to a set distance. The pipette is plunger is actuated to three points, two fixed and one adjustable. The fixed points are the dispensed point, when the plunger is all the way down, and the reset point, when the plunger is ready to withdraw fluid. The adjustable point is the set point, which

Figure 1. CAD rendering of printable parts. Three parts are printed: the body, plunger shaft, and luer-lock adapter for pipette tips.

Figure 2. Photos of pipette. The pipette is composed of three printed parts, a 1 mL syringe and some additional hardware.

determines the volume of fluid that will be drawn into the pipette and depends on the position of the screw. The system is spring loaded towards the set point. A spring notch, in the plunger shaft part, and a groove, in the body part, hold the plunger at the reset position where it can be released by pressing in the notch. A 1 ml BD syringe twists to lock into the body part. An additional printed part adapts standard micropipette tips to the luer fitting of the pipette. Our printed pipette mimics commercial pipettes is design, function, and user operation, and is intuitive to use. 3D parts were designed in Blender and SolidWorks and printed by Fineline Prototyping via selective laser sintering. Additional materials include a spring, a nut and bolt and two washers.

Validation

The pipette was validated and compared to a commercial pipette. The pipette was tested to see if the set point would drift between during use for example small, incremental movements of the screw or other parts causing the pipetted volume to drift. To test the pipette the same volume was pipetted times without moving or re-adjusting the set point. The printed pipette's accuracy and precision was characterized and compared to a commercial pipette. The printed pipette and a series of commercial pipettes were tested at volumes of 20 μL 50 μL and 200 μL. The printed pipette was adjusted to the the target volume by eye from the syringe graduations, and the resulting volume was measured and repeated 5 times to account for variability. Measurements were taken from the commercial pipette in a similar way. To test user friendliness and feasibility for using the pipette without verifying with a scale, data was also gathered from novice users. After a quick overview of the operation of the pipette measurements were taken after the volunteers adjusted the pipette to 200, 50, 20 and 10 μL. After the first attempt was measured on the scale the volunteer was allowed to adjust the set point and re-measure until within 15% of the target volume was 58 reached.

Figure 3. Novice User efficacy. Novice users were asked to pipette volumes of 200, 50, 20 and 10 μL without the use of a scale.

Results and Discussion

Our printed pipette had a comparable accuracy to a commercial pipette (Table 1). The commercial pipette has a digital readout that allows the user to adjust precisely to set values where the printed pipette is adjusted by eye according to graduations. This is certainly the cause of the lower accuracy and wider deviation although it's performance is impressive.

The novice user data demonstrates that the pipette set point is user friendly and is capable of accurate measurements without validating with a scale (Figure 3).

For more information, see **??**.

Table 1. Comparison of Accuracy and Precision

Target Volume	20 μL	50 μL	200 μL
Printed Pipette	196.4 $\pm$ 2.2	53.5 $\pm$ 1.8	19.5 $\pm$ 0.6
Commercial Pipette	204.5 $\pm$ 2.9	49.9 $\pm$ 0.1	19.9 $\pm$ 0.2

Average measured volume by weight and standard deviation.

Supporting Information

References

1. Fullerton JN, Frodsham GCM, Day RM. 3D printing for the many, not the few. Nature Biotechnology. 2014;32(11):1086–1087. Available from: `http://www.nature.com/doifinder/10.1038/nbt.3056`.

2. Waldbaur A, Rapp H, Länge K, Rapp BE. Let there be chip—towards rapid prototyping of microfluidic devices: one-step manufacturing processes. Analytical Methods. 2011;3(12):2681. Available from: `http://xlink.rsc.org/?DOI=c1ay05253e`.

3. Zhang C, Anzalone NC, Faria RP, Pearce JM. Open-Source 3D-Printable Optics Equipment. PLoS ONE. 2013;8(3).