Multichannel Pipetting: How to Choose the Correct Pipettor

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Multichannel pipettors are widely used in microplate work, including serological testing, molecular biology, immunology assays, and polymerase chain reaction (PCR). The explosion of specific markets such as genome projects and drug discovery has further increased the use of the microplate. Because microplates are currently being used in very labor-intensive applications worldwide, there is a need to increase productivity, maintain accuracy and precision, and reduce physical stress. Each of the approximately ten multichannel pipettor manufacturers emphasizes ergonomics, comfort, ease of use, and safety. Despite this, many users have problems with performance, tip mounting, tip sealing, and tip ejection. The key question is: How does one choose the correct multichannel pipettor? Following are a few criteria that should be considered when choosing a multichannel pipettor.

Ergonomics

All manufacturers claim that their pipettors are ergonomic. However, there exist clear differences in pipetting and tip ejection force as well as in weight, length, and design. For example, the difference between the lightest instrument, the mLINE® (**Biohit Plc,** Finland) (*Figure 1*), and the heaviest is more than 100 g (137 vs 241 g) (*Table 1*). Usually, the shorter and lighter the pipettor, the more ergonomic it is to use. However, more important than weight is the balance and fitting of the pipettor to the hand of the user. This is because good stability considerably reduces the strain on the muscles of the hand.[1] Most, but not all, multichannel pipettors have a finger support to secure better fitting. Table 1 lists available mechanical multichannel pipettors and their features.

Ease of use

An important feature in multichannel pipettors is the ability to turn the liquid end to an optimal position, for example, when pipetting to microplates (Figure 1). However, many pipettors allow rotation only in one direction, since rotation in the other direction will disassemble the liquid end from the handle. In some models, the connecting nut has to be tightened after adjusting. To avoid accidental disassembling, which leads to a loss of accuracy or even leakage during pipetting, one should ensure that the pipettor chosen allows 360° free rotation without a need for tightening. The mLINE instrument features this ability.

Pipettors that are color-coded and have large, clear numbers are easier to read and use. This is also the case with the mLINE unit; in addition, the volume adjustment is stepless, extremely light, and fast to adjust. Most importantly, the volume is locked after adjustment to avoid accidental alteration of the volume during pipetting.[2] To avoid this, many pipettors on the market have adjustment systems that are extremely heavy to turn, particularly while wearing gloves.

Pipetting force, accuracy, and precision

There exists much variation among different manufacturers in the specifications for instrument accuracy and precision (Table 1). This regards not only the guaranteed specifications but also the pipetting force, which has an influence on accuracy. The force needed to depress the plunger to the first position varies from 8.7 to 20 N, depending on the manufacturer and the pipettor in use; for the blowout, that number goes up to 45 N (4.5 kg).[3] In conventional pipettors, the smaller the volume, the more thumb force that is demanded to operate the plunger. High force, together with small movements, cannot be repeated with the same accuracy after hundreds of pipettings. If one is pipetting more than 1000 samples a day with a conventional mechanical pipettor, it is no surprise that serious fatigue in the muscles of the hand occurs, which can ultimately lead to repetitive strain injuries (RSI).

The mLINE pipettor is lightweight, and the patented spring mechanism,[4] combined with low-friction sealings and grease, ensures that less pipetting force is required (*Figure 2*). The spring mechanism allows the user to pipet with a constant and very low force, regardless of the volume, which has a direct effect on pipetting accuracy. The smaller the force needed for minute piston movements (small volumes such as 0.5 µL), the easier it is to pipet accurately.

Due to the instrument's design, the maximum pipetting force of the mLINE is lower than the minimum pipetting force of pipettors produced by most other manufacturers. mLINE demands four times less work from the user than conventional pipettors. The low pipetting and tip ejection force ensures that precision values easily stay within specification, even after prolonged hours of pipetting. Moreover, because the operating mechanism is thermally insulated from the handle, the warmth of the hand does not affect pipetting results at all, which may be the case with other pipettors, especially after several hours of continuous pipetting.

Figure 1 The mLINE pipettor features very light pipetting and tip ejection force.

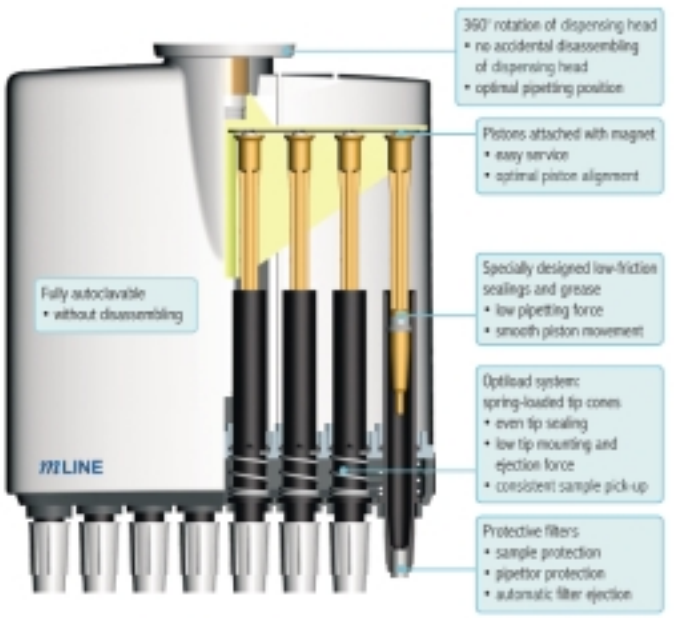

Figure 2 The mLINE pipettor features individual piston/tip cone assemblies, spring-loaded tip cones, low-friction sealings and grease, and full autoclavability.

Tip sealing and tip ejection force

Tip mounting and ejection demands much force in multichannel pipetting, and is directly related to tip sealing and the force with which tips are being mounted to the pipettor. Since the pipettor and the tip are designed as a system to ensure a perfect fit, only tips specified by the pipettor manufacturer should be used. A compromise in tip selection may result in uneven sample pickup, especially with 12-channel pipettors.

However, even when the tips of the original manufacturer are being used, traditional multichannel pipettors require a high insertion force, up to 10 kg, because of the large sealing area. This, in turn, leads to massive force needed to eject the tips, especially when using 12-channel pipettors. The tip ejection force with multichannel pipettors can vary up to

Table 1 Features of different multichannel pipettors available on the market

	Biohit		Brand C				Brand E			
	mLINE	Proline	Brand A	Brand B	Product 1	Product 2	Brand D	Product 1	Product 2	Brand F
Weight (g)*	137	164	200	230	241	189	223	167	210	164
Length (mm)	242	252	250	255	235	245	241	245	240	220
Pipetting force to first stop (N)*	8.7	12	10	20	11.5	14	13	14	20	9.3
Blowout force to second stop (N)*	19	24	22	45	29	32	26	27	36	22
Models 8/12-channel (in µL)	0.5–10 5–100 30–300	0.5–10 5–50 50–300	0.5–10 10–100 30–300	20–200	1–10 5–50 30–300	0.5–10 5–50 50–300	0.5–10 2–20 20–200 20–300 100–1200	0.5–10 5–50 40–350	1–10 10–100 20–200	0.5–10 2–20 2.5–25 5–50 10–100 20–200 30–300
Autoclavable	Yes	No	Lower parts only	No	Yes	Yes	No	Yes	Yes	Lower parts only
Display	Visible during pipetting	Visible during pipetting	Visible during pipetting	Covered by hand during pipetting	Visible during pipetting	Visible during pipetting	Covered by hand during pipetting	Visible during pipetting	Visible during pipetting	Visible during pipetting
Optiload tip mounting	Yes	No	No	No	No	No	No	No	No	No
Type of tip cones	Hard	Elastomer	O-rings	Hard	Hard	Hard	Hard	Hard	Hard	O-rings
Tip cone filters	Yes	Yes	No	No	No	No	No	No	No	No
Tip cone filter ejection	Yes	No	No	No	No	No	No	No	No	No
Free rotation of dispensing head	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Inaccuracy at 300 µL	0.60%	0.70%	0.60%	1.00% (200 µL)	1.00%	1.00%	0.80%	0.80% (350 µL)	0.70% (200 µL)	0.60%
Imprecision at 300 µL	0.25%	0.25%	0.30%	1.60% (200 µL)	0.30%	0.30%	0.15%	0.30% (350 µL)	0.30% (200 µL)	0.30%
Increment (300-µL pipettor)	0.2 µL	5 µL	0.2 µL	—	1 µL	5 µL	0.5 µL	0.4 µL (350 µl)	1 µL (200 µl)	1 µL
Warranty	3 years	3 years	2 years	1 year	3 years	3 years	1 year	3 years	3 years	1 year
CE marked (IVD 98/79/EEC)	Yes	Yes	Yes	No	No	No	No	Yes	No	Yes

*Measurements have been carried out in the Biohit R&D department by using force measurement equipment: the Mecmesin Imperial 2500 (**Mecmesin,** Slinfold, West Sussex, U.K.) and DS-671 digital weighing scale (**Teraoka Electronics,** Shanghai, China).

threefold depending on the number of channels, tip mounting force, manufacturer, and model. Some manufacturers even recommend rocking the pipettor over the tip rack and tightening the tips by hand to ensure secure tip fitting. This is both time-consuming and causes a possible risk of contamination. Without doubt, it results in laborious tip ejection requiring much force. O-rings or elastomer tip cones eliminate that problem, but require maintenance rather often, and wear particles can contaminate samples. The mLINE Optiload system features spring-loaded tip cones (*Figures 2* and *3*) that allow pipettor tips to be picked up easily with a constant low force. In practice, tips cannot be sealed too tightly to the tip cones, which prevents overinsertion and jamming of the tips. This system ensures that all tips are always sealed on the same height, which is particularly important in microplate pipetting, in which it is necessary that all 12 tips reach the well bottom evenly. Thus, the springs secure optimal, even tip sealing and consistent sample loading, and reduce tip ejection force considerably, up to 65% (Figure 2). Moreover, the tip ejector design has a large, rounded surface, which makes it convenient for users and allows one-handed, low-force tip ejection. Thus, when hundreds of tip ejections are performed daily, optimal tip loading and ejection significantly reduces the risk for RSI.

Volume range

Much variety exists in the volume ranges of different multichannel pipettors. For example, if 50 µL is to be dispensed, the range can be as follows: 50–300 µL, 30–300 µL, 40–350 µL, 20–200 µL, or 20–300 µL, depending on the manufacturer. However, a large volume range should not come at the expense of compromised accuracy and precision, which is often the case (Table 1). Even at low volumes, the piston travel of the mLINE instrument is longer than usual, which makes pipetting more accurate in small volumes. In addition, the minimized dead volume, i.e., the air space between the tip and the piston, further improves accuracy.

Protective tip cone filters and filter ejection

Pipettors are contaminated very easily if no protection is used (filter tips or filter in the pipettor tip cone). Even when working with buffers or aqueous solutions, small amounts of liquid may get inside the tip cone, causing contamination. Special attention should be paid to this problem when working with infectious, radioactive, or DNA samples. An economical and effective way to protect both the pipettor and the sample from contamination is to use a filter in the pipettor tip cone.[5] Standard tips can be used with the tip cone filter in many applications, instead of the more expensive filter tips. This feature is offered on Biohit multichannel pipettors (Table 1). Moreover, the mLINE features a thumb-activated filter ejection system with which the filters can be removed safely without the user touching them (*Figure 4*).[6] Very often, the filter is enough to protect the pipettor. However, only autoclaving ensures that

Figure 3 The Optiload system features spring-loaded tip cones that allow pipettor tips to be picked up with a constant force. This, in turn, ensures even tip sealing and sample pickup, and considerably reduces tip ejection force compared to conventional pipettors.

the pipettor is virtually free of dangerous pathogens or the agent of concern.

Decontamination and autoclaving

Easy disassembling and autoclaving are regarded as important features for pipettor maintenance. To be able to autoclave the entire pipettor without disassembling the liquid end or having to change the O-rings that many multichannels feature is always an advantage, even if total disassembling is sometimes needed for cleaning. However, there are also convenient and effective decontamination solutions available on the market, which require simple spraying and wiping instead of time-consuming autoclaving.[5]

When choosing a multichannel pipettor, the user should make sure that it is fully autoclavable; in many pipettors, only the lower part can be autoclaved or the unit is not autoclavable at all. If autoclaving is done frequently, the pipettor, like the

Figure 4 With the instrument's filter ejection mechanism, filters can be removed simply by pressing the piston all the way down to the third position.

mLINE, should be fully autoclavable (numerous cycles) and should not need prior disassembling.

Calibration and in-house service

When purchasing a multichannel pipettor, the user should make sure that it is CE marked, and can easily be calibrated and serviced in-house when necessary. In many multichannel pipettors, service is time-consuming, requiring extra tools and many different parts to be disassembled, cleaned, and reassembled in the correct order. This makes self-service practically impossible, especially if one broken tip cone requires a time-consuming change of the whole liquid end. For the user to be able to service the pipettor quickly and effectively, the multichannel pipettor should have individual piston/tip cone assemblies, and only 1–2 parts to be cleaned, as is the case with the mLINE. The calibration of the instrument has been made to be as user-friendly as possible. The calibration tool, which also acts as a tube cap opener, enables fast and accurate calibration. Most importantly, it allows fine adjustment. Due to a special transmission mechanism, even very small increments in calibration can be done easily and safely.

Conclusion

There are several types of multichannel air displacement pipettors on the market. The best way to find the right tool for each application is to go through the pipetting procedures and find out which pipetting techniques and volumes are needed. However, less force in pipetting and tip ejection means less fatigue and discomfort, which results in improved productivity and user satisfaction. Therefore, one should look for a light, low-force, ergonomic multichannel pipettor that does not compromise accuracy and precision. It is preferable that tips designed for the particular pipettor are used. Before choosing a multichannel pipettor, the user should ask for a trial run to test the instrument. The best decision comes through evaluation of one's own experience.

References

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