Phaco Needle Design Parameter Effects:
Factorial Design Modelling

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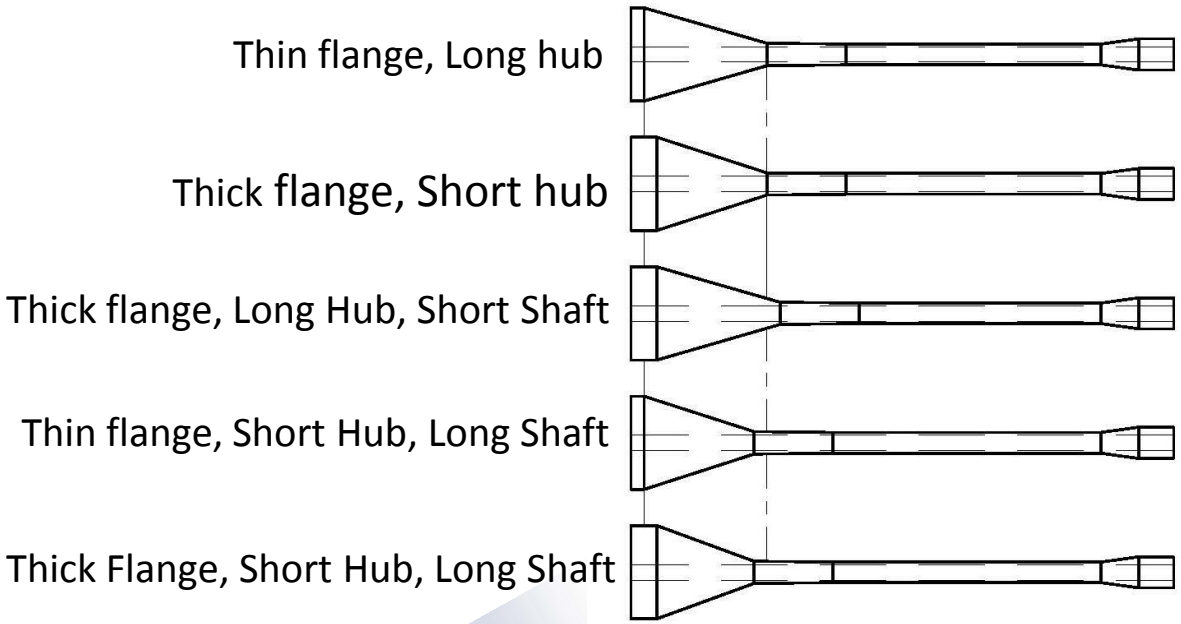
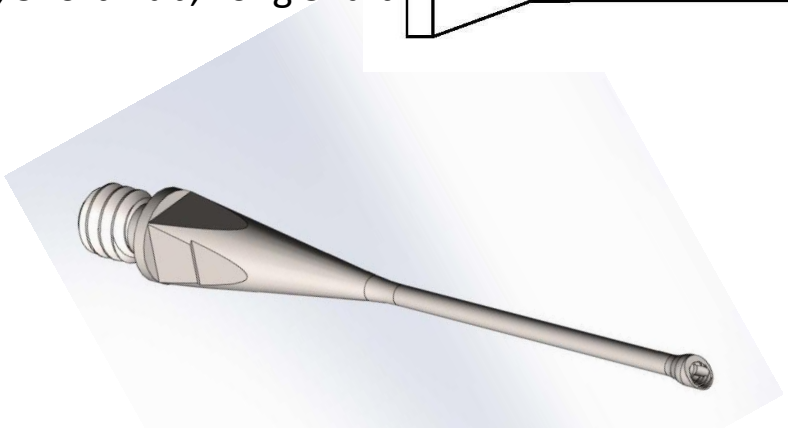
Financial Disclosure: I am the designer & patent holder of needles designs used in this study

Needle Design Parameters

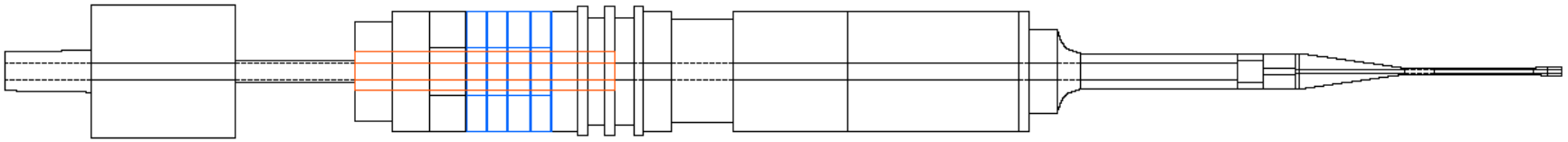
There are many parameters to consider in needle design. All have some effect on the performance of the handpiece during surgery.

For example:



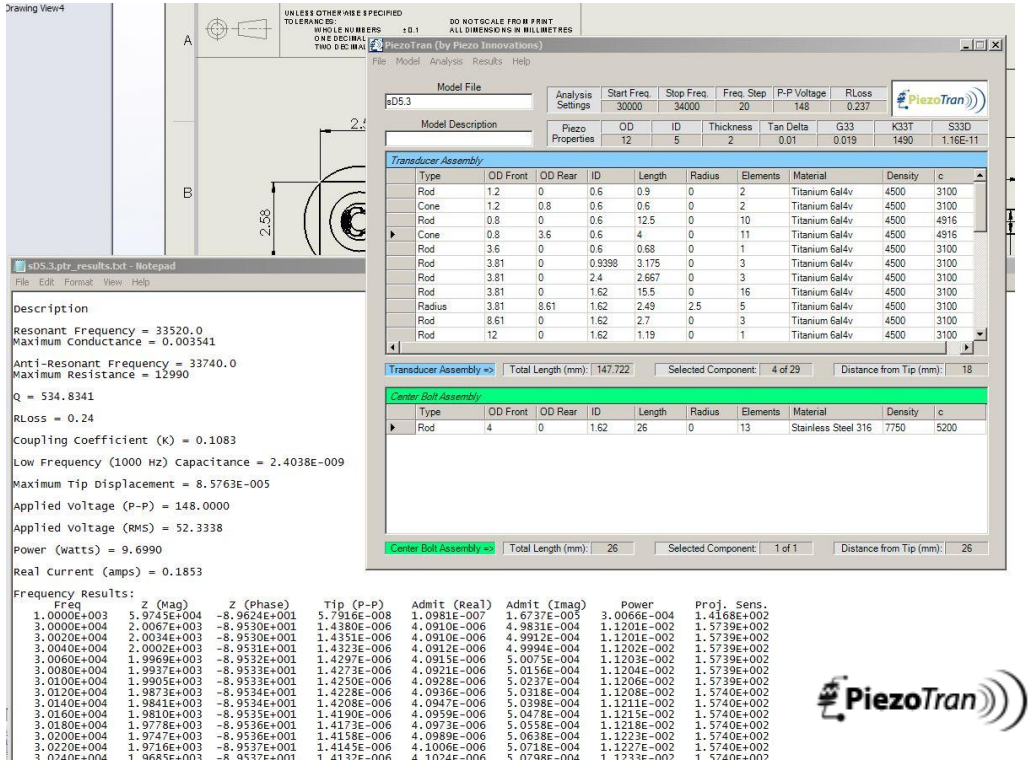


The PeizoTran Modelling Software



The PeizoTran modelling software allows for detailed examination of phaco hand-piece performance as well as the effect of various needle designs.

Along with various electrical effects, the model output describes the effect on tip excursion which is one of the main determinants of cutting efficiency.



PiezoTran

PeizoTran Model Output

Parameter Changes Examined:

shaft length and thickness, hub length, and flange thickness.

Flange Outside Diameter	3.6	3.6	3.6	3.6	3.6
Flange Thickness	0.5	0.5	0.5	0.5	1.0
Hub Length	4.0	4.0	4.0	3.5	4.0
Shaft Inside Diameter	0.6	0.6	0.6	0.6	0.6
Shaft Outside Diameter	0.8	0.8	0.9	0.9	0.9
Shaft Length	14	12	14	14	14
Tip Diameter	1.2	1.2	1.2	1.2	1.2
Tip Length	0.9	0.9	0.9	0.9	0.9
total Length	20	18	20	19.5	20.5
Needle Weight	131.4	129.4	139.6	122.4	153.2
max Displacement (um)	**18.99**	**29.42**	**27.78**	**18.65**	**20.73**

Parameter Change Effects

- shortening the *shaft length* substantially increased displacement, reducing weight*.
- increasing the *shaft diameter* also substantially increased displacement, but increased weight.
- A *longer hub* produced some increase in displacement with a big increase in weight.
- A *thicker flange* produced some increase in the displacement, also increased weight.

* weight differences may not enable the handpiece to tune, although the tuning window is broad

Design Changes vs Surgical Outcomes

- Seven different straight needle designs were evaluated at surgery
- Prospective Audit - 520 cataract operations
- All were evaluated for density of Nucleus Sclerosis using LOCS by the same physician
- All operations used Divide & Conquer technique
- Torsional Mode only – all with same settings throughout (sculpt & segment extraction)
  - 75 cm Irrigation, 250 mmHg vacuum, 25 mL/min flow
  - burst mode power on 50 msec, minimum 80 msec off.

Cataract Weight & Density Increases with Age

It is not widely understood that older patients have ***more*** cataract that is also harder. Both influence the efficiency of surgery.

Spencer RP, 1976

Ann Ophthalmol, Apr;8(4):440-1.

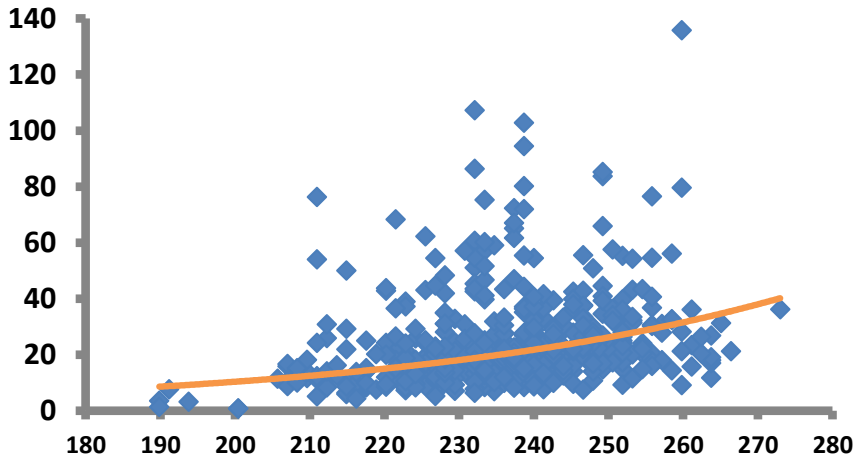
Pathological study of lens weight change with age:

(1.32*age)+141

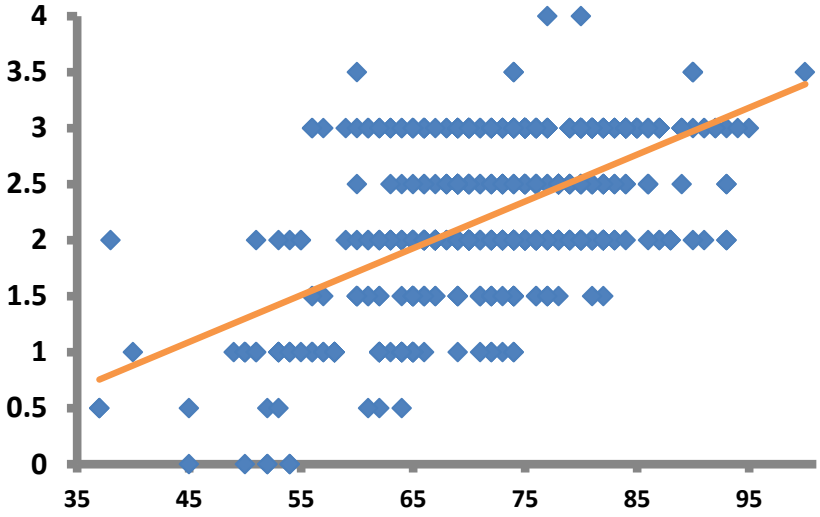
Around 24% increase in weight from 50 to 80 years of age.

Unless accounted for,
the cataract weight difference with age will confound the analysis.

Ust more cataract requires longer ultrasound time

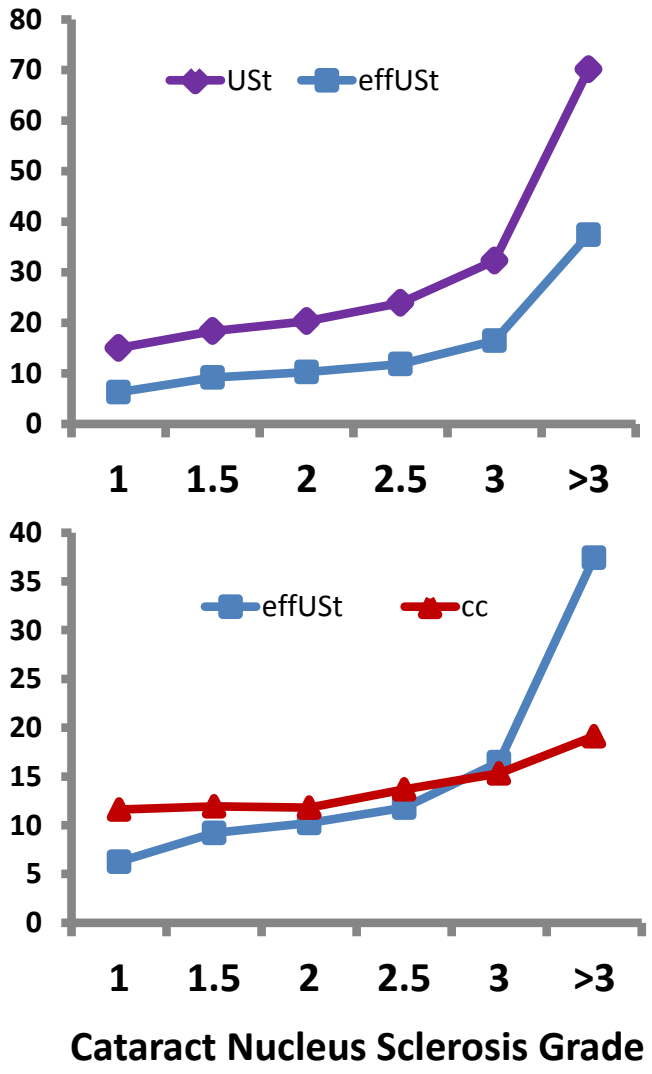


Grade older patients have harder cataracts



Surgical Measures

- Accounting for the torsional amplitude:
  - Percent Torsional Amplitude is the measure of needle tip excursion
  - effective ultrasound time = ultrasound time x amplitude (%)
- What about the fluidics?
  - cataract extraction = emulsification + aspiration
  - We also need to account for the fluidics at the same time



*flow*Phaco

- The phacoemulsification surgery involves the process of cutting with aspiration
- *flow*Phaco is a summary measure combining the ultrasound energy with fluidics:

grams cut

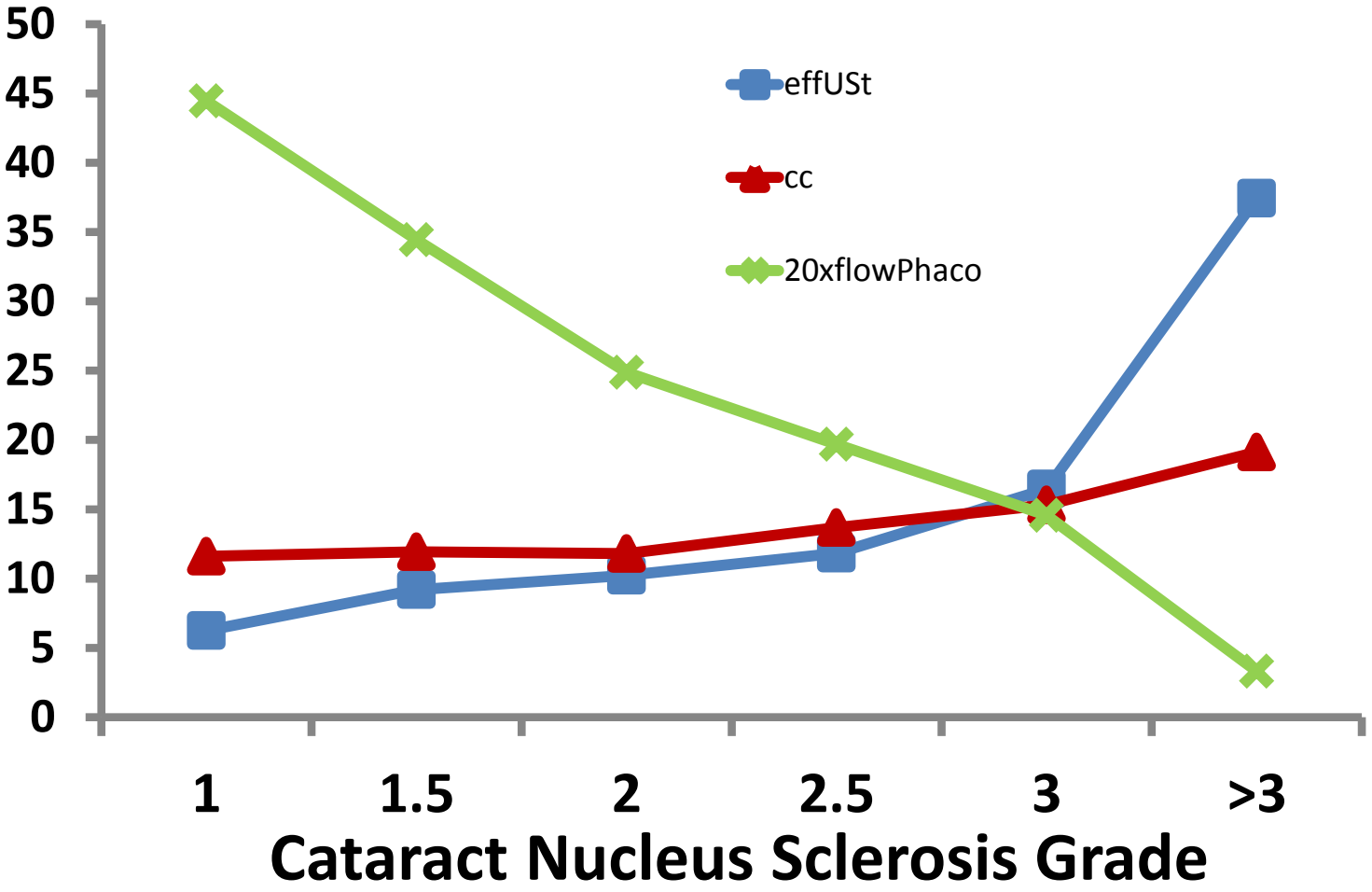
per cc

over the effective ultrasound time

So the transformed measure, *flow*Phaco can account for cataract weight, tip amplitude, and aspiration volume, as well as the ultrasound time.

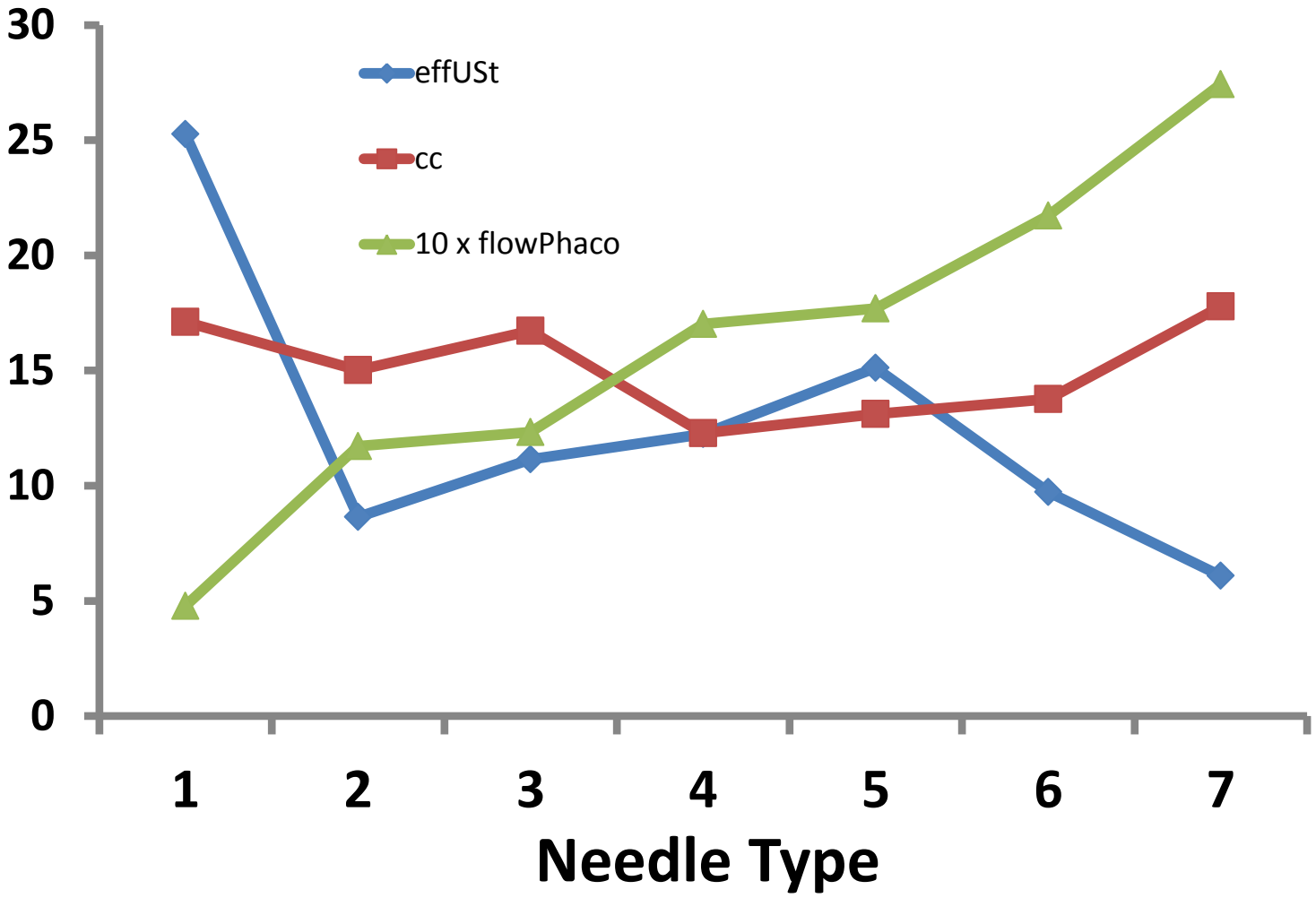
Nice Summary Measure

*flow*Phaco produces a near linear transform that allows for separate analysis of cutting efficiency by cataract density



Needle Design is Important

Efficiency differences in the needle tip design become more evident with the transform measure *flow*Phaco



Conclusions

- Subtle changes to the phaco needle design parameters effect the performance
- PeizoTran provides a useful model to assess the effect of some design parameter changes
- Different needle designs can improve phaco surgery efficiency
- *flow*Phaco is a useful summary measure to compare the surgical outcomes