

Force Feedback as A Surgical Learning Aid: A Preliminary Study on Suture Tying



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Traditional Open Surgery Skills Training

In surgery, tissues must be cut, re-attached, passed through, and wrapped around each other. It is essential that the newly joined tissues have appropriate mechanical load-bearing capacity, ensuring bodily function is not impaired and post surgical injury does not occur. For example, bodily fluid flow should not impeded by overly constricted conduits, load bearing tissues should be taut enough to support their loads, and tissue connections should not be over-tensioned to the point of rupture. A major obstacle in training surgeons is conveying precisely what these appropriate loads are. Trainees have no direct feedback and can only mimic the trainer and use guesswork to estimate the right amount of force.



Canonical suture tying practice. The trainee must guess the right amount of force when tying knots

Quantitative Feedback as a Learning Aid

Our goal is to remove the uncertainty of traditional suture tying training and provide quantitative force feedback to instructors and trainees via a visual display.

A surgical knot tying training protocol was defined using silicon wound training phantoms. Two groups of eight inexperienced participants performed a wound closing stitch and suture knot tying task. The cohort included adults (age > 18). Exclusion criteria was prior surgical knot tying experience. 6-0 USP polypropylene monofilament sutures were instrumented with a force meter.

Methods and Procedures for Quantitative Feedback Skills Assessment Training

Knot tying technique was demonstrated to participants. In the experimental case a readout of force applied by trainees was provided. In the control case the readout was masked. Trainees tied six knots as closely to a “optimal” 230 gram tension as possible. We discarded the first three knots which were used to guide participants on knot tying technique. Knot tensions recorded by the meter were summed to a total score

Equipment	Function
6-0 USP mono suture	Suture with consistent and characterized tensile strength used to train surgical knot tying
Wound Block	Silicone incision phantom used to simulate wound closure during skills training
Force Meter	Quantitative feedback apparatus used by the experimental group to learn optimal tying force

Skills Acquisition Results

Tables 1 and 2 show raw scores in our knot tying experiment Table 3 is a statistical analysis comparing our experimental data. We compared the L1 norm of each total score in Tables 1 and 2 using a t test between conditions of mean absolute difference from optimal tension for the control and experimental groups.

Knot Tension in grams			
Score 1	Score 2	Score 3	Total Score
0	0	180	180
0	0	0	0
0	70	70	140
60	60	60	180
0	310	0	310
5	70	85	205
60	65	90	215
90	0	225	315

Table 1: Control Group Knot Tension

Knot Tension in grams			
Score 1	Score 2	Score 3	Total Score
170	0	120	290
50	100	220	370
195	130	225	550
180	235	235	650
290	230	225	665
210	230	225	665
170	250	215	635
225	260	215	700

Table 2: Experimental Group Knot Tension

	Control	Experimental
Mean	165.6	44.4
Median	170	12.5
Standard Deviation	77.7	68.5
Minimum	5	0

Conclusion

Our results indicate force feedback has potential as a training aid:

- Knot tension was more closely distributed about the optimal force in the experimental case
- Breakage was more common in the control case (n=9)
- We are able to reject the null hypothesis that the control group had lower deviation from optimal knot tension with $p < 0.01$