

INNOVATION

The Hand

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By Alan Mudd
alanm@farmpd.com

Surgical Tool Design

DRIVEN BY USER COMFORT



Designing a product to be operated by the human hand represents a significant challenge for the industrial designer—not only because of the hand’s complex geometry, variations in size and intricate range of mechanical motion, but also because it’s the part of the body that expresses our unique abilities, whether that’s a talent for playing the piano, building a ship model or performing life-saving surgery. When tasked with designing any handheld tool or product, designers understand that personal differences in physical user interaction may be very subtle (how many different ways have we seen people hold a pen?). Yet by acknowledging and accommodating these differences, the designer can make huge improvements in how the user experiences the product.

Farm Design collaborated with ConMed, a global manufacturer of surgical devices, to develop an improved version of its DetachaTip laparoscopy (“lap” for short) tool handle. Our team was challenged to design *and* engineer a new reusable (extended-use disposable) handle that would be more comfortable and offer greater control and precision than ConMed’s previous product.

Specifically, the handle needed to address the differences in hand ergonomics and the personal working preferences of different surgeons. At the same time, the controls on the handle had to be accessible for right- or left-handed use, and we had to design the handle ergonomics for the increasing number of females in the surgical

profession without compromising the fit of a large male hand. Finally, despite being a limited-use instrument, we needed to engineer the product with high-quality durable materials and provide the precise feel of a long-term reusable device.

The Challenges of Laparoscopic Surgery

Lap tools are used in minimally invasive surgery. They typically consist of a scissor-like handle to which is attached a long, slender shaft that is inserted into the patient through a device called a trocar, which acts as a portal through the outer layers of tissue and into the surgical cavity. Operating the handle drives the action at the tip, allowing the surgeon

Alan Mudd is the technical marketing manager at Farm Design. His background combines years of award-winning medical product development experience with a passion for design storytelling. He's worked for clients ranging from global players like Samsung and Siemens to medical technology startups like Insulet, and holds a BS in product design from Art Center College of Design.



to manipulate or cut tissue inside the patient while being guided by the fiber optic video taken from inside the cavity. Surgical device companies typically offer an entire lap tool system that consists of the proprietary handle and a family of interchangeable tool shafts with various functions at the tip, such as grasping, cutting or cauterizing.

Laparoscopic surgery is effectively surgery by remote control, and is particularly challenging because of the unique interaction among the surgeon, the tools and the patient. In a typical open-cavity surgery, the physician is looking directly at the targeted areas using conventional surgical tools that put the surgeon's fingertips in direct contact with the patient. When using a lap tool, the doctor is standing next to the patient table viewing a screen showing the image of what's happening inside the patient and manipulating a tool whose cutting or grasping action is being done about 18 inches from the surgeon's hands. In addition to being somewhat disconnected visually from what's going on at the end of the tool, the doctor is missing the direct tactile feedback of a blade or a probe touching tissue. The challenge for Farm was to design a lap tool handle that would offer many subtle but significant improvements over existing products, adding up to a more comfortable, precise and satisfying user experience.

Addressing Hand Ergonomics and Varied Working Styles

To capture the uniquely complex and detailed interaction between laparoscopic surgeons and their tools, during a four-year period our client had conducted comprehensive research into surgeons' experience with handles made by both ConMed and its competitors. The detailed results of that research drove the interaction design of the new product. For example, the research introduced us to a phenomenon called "laparoscopic surgeon's thumb" where surgeons develop parasthesia (numbness or tingling) from pressure put on the lateral digital nerve of the thumb by the thumb loop on the handle. This led us to pay specific attention to both the shape of the finger loops and the sculpting of all surfaces that the fingers would touch.

We also learned from watching laparoscopic procedures that surgeons typically hold the tools in a wide variety of orientations relative to the patient, so we had to consider and optimize the angle between the finger loops and the tool shaft in order to mitigate stress on the surgeons' wrists. And we had to define just the right amount of rotational travel for the thumb loop, providing enough mechanical advantage to properly activate the tool end without creating so much travel that it would be difficult for a smaller hand to operate.

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Finally, our team understood that we could create a truly differentiated product if we designed it for the varied approaches that surgeons use for gripping the handle. Surgeons usually hold the handle like a pair of scissors, but in order to rest their hands during a long procedure, they often shift to a technique called palming, where they cradle the handle with the thumb loop resting in the palm of the hand, a slightly more relaxed approach that uses different muscles and reduces stress. And yet another common grip approach is used when the tool must be held almost vertically with the surgeon's hands held relatively high. In this case, the surgeon interacts with different areas of the handle and might even push against the bottom of the thumb loop.

Building on this extensive user and market research, Farm began a process that involved designing the form of the handle—including the tactile and mechanical interaction

points—and engineering the internal mechanisms and snap-on tool shaft interface. As our team progressed along the development path, we validated our ideas by sharing sketch models and machined prototype concepts with surgeons. Their feedback guided the refinement of the handle features, form and touchpoints.

As the overall form and interaction was evolving, Farm's engineers developed the part design and internal mechanisms that would fulfill another critical aspect of the product performance sought by ConMed and our team: a high level of precision in the operation of the product. All moving parts had to interact smoothly and with no discernible play. And we had to engineer into the handle operation the pronounced auditory clicks requested by surgeons to indicate how far they had closed the tool tip or rotated the tool shaft.

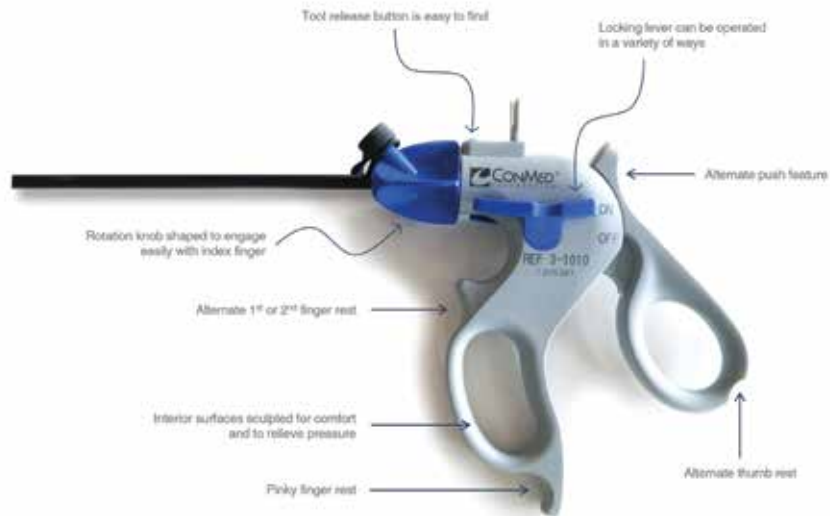
A Better Product for the Users and for ConMed

With the new DetachaTip handle design, Farm and ConMed have created a form that perfectly fits the hand:

- The handle accommodates all five fingers comfortably when held traditionally or palmed.
- The handle size and range of motion fit a wide range of hands, from small female to large male.
- Handle surfaces have been carefully sculptured to significantly reduce pressure points.
- The generous finger contact surface areas are designed for comfort while maintaining a compact overall handle size.
- The finger rest at the base of the handle is narrower and farther forward to accommodate the smaller pinky finger.
- The interaction area on the bottom of the thumb loop gives the user another grip option when operating the handle at a higher angle.
- The places where a glove might get caught when operating the thumb loop were minimized.
- The primary handle parts are injection molded with a light texture that's easier to grip.

The team also devised controls that are fully ambidextrous:

- The pivoting seesaw handle lock lever means it can be activated from a variety of positions.
- The tapered shape of the lock lever keeps it out of the way during use.
- The tool shaft rotation knob is easy to reach and carefully shaped for precise control by the index finger.
- The tool release button is placed on top where it's easy to see and where there's less chance of accidental activation.
- There are no triggers or buttons on the front of the handle so as not to interfere with the surgeon's natural squeezing motions.
- The handle lock, rotation knob and release button are molded in contrasting colors so they're easy to see.



To further enhance the user experience, the new DetachaTip handle weighs less than many competitors' products, yet balances well when a tool shaft is attached. The handle is constructed to communicate premium quality. Rotational parts turn with satisfying precision, and when comparing the ConMed handle to any other lap tool on the market, there is a noticeable lack of play where parts interact and a much better feel in the hand. When held, the user's fingers naturally fall into a comfortable position, no matter which grip approach is used, and it's easy to access all controls. Ed Connell, from ConMed's marketing team, had this to say: "When we put the new DetachaTip handle into a surgeon's hand for the first time, they initially think it feels weird. But then they start to operate it, and I watch their expression shift as they suddenly realize that every handle they've ever used has been far less comfortable than this. Every surgeon who tries this tool loves it."

By focusing the design effort on the unmet needs of the end user, Farm and ConMed have created the most comfortable and easy-to-use tool handle on the market, a compelling addition to the laparoscopic devices currently available to surgeons and a product that is boosting ConMed's bottom line. ■