Device directs sperm to 'go against the flow' to help infertility

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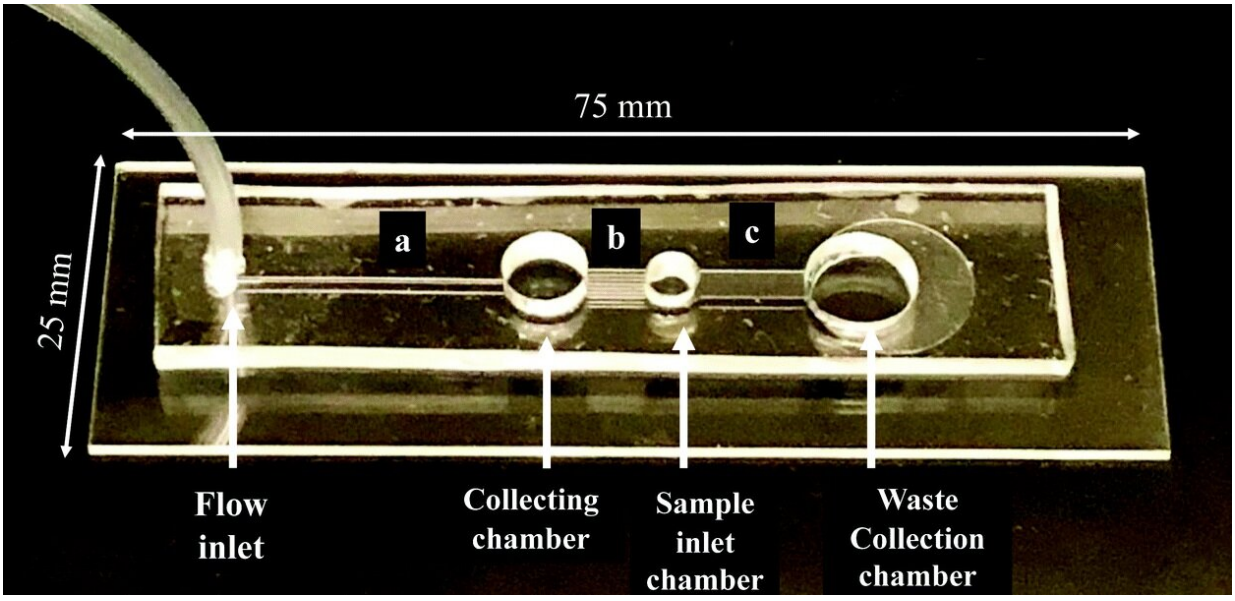

The microfluidic chip consists of four cylindrical chambers connected through microchannels: the fluid inlet chamber, collecting chamber, sample inlet chamber, and waste collection chamber. Credit: Florida Atlantic University

The female genital tract can be a hostile environment for conception. Out of about 100 million sperm, only a few hundred make it to the fallopian tubes. Guided by a directional movement called rheotaxis, sperm cells swim against the cervical mucus flow to reach the egg for fertilization. This journey, however, is even more critical when considering infertility. Sperm motility—the ability to swim the right

way—is key.

By taking advantage of this natural rheotaxis behavior of sperm, researchers from Florida Atlantic University's College of Engineering and Computer Science have developed a microfluidic chip for sperm sorting that is fast, inexpensive, easy to operate and efficiently isolates healthy sperm directly from semen. Importantly, it effortlessly collects sorted sperm cells from the collecting chamber while minimizing contamination by deformed or dead sperm cells.

Assisted reproductive technologies such as in vitro fertilization (IVF), intrauterine insemination and intracytoplasmic sperm injection all require healthy sperm cells for a successful outcome. Current centrifugation methods for sperm sorting require multiple steps, multiple types of equipment and take about two hours to isolate sperm cells. These methods damage sperm during processing and induce significant DNA fragmentation and oxidative stress.

Results of the study, published in the journal *The Analyst* of the Royal Society of Chemistry, showed that sperm cells isolated from the collecting chamber in this microfluidic chip exhibited significantly higher motility (almost 100 percent), a higher number of morphologically normal cells and substantially lower DNA fragmentation, which is a crucial parameter for the fertilization process. In addition, the developed chip provides more than enough cells required for a successful intracytoplasmic sperm injection due to the amount and quality of sperm cells isolated using the chip.

"Operating our chip is very easy. Once the semen is loaded into the sample inlet chamber, the competent sperm cells start moving against the fluid flow toward the collecting chamber from where they can easily be collected," said Waseem Asghar, Ph.D., senior author, an associate professor in FAU's Department of Electrical Engineering and Computer

Science, and a member of the FAU Institute for Human Health and Disease Intervention (I-Health) and FAU Institute for Sensing and Embedded Network Systems Engineering (I-SENSE). "Furthermore, this chip offers a one-step, one-hour operational benefit, which an operator can use with minimal training."

The study also validates that rheotaxis selects the healthy, motile, and higher velocity sperm cells for the fertilization process.

"The assembly of the microfluidic chip is low-cost, and the reagents used in the chip to separate sperm cells are only a few milliliters, therefore, the commercial cost of the chip would be less than $5," said Asghar. "Moreover, this technology will considerably reduce the economic burden of fertility implementations and both the chip and the sperm cells isolated from it offer great clinical significance and applicability."

The microfluidic chip consists of four cylindrical chambers that are connected through the microchannels. The four chambers are the fluid inlet chamber, collecting chamber, sample inlet chamber, and waste collection chamber. The channel between the collecting chamber and sample inlet contains microgrooves to guide the sperm cells in addition to the fluid flow for the rheotaxis movement of the sperm cells towards the collecting chamber.

The shear stress inside the device is generated by fluid flow using a syringe pump. A raw semen sample is then added to the sample inlet chamber from where functional sperm cells will swim towards the collecting chamber, effectively separating themselves from dead and immotile sperm.

"Conventional centrifugation often compromises the integrity of sperm cells. This research study demonstrates that the microfluidic chip

developed by professor Asghar and his colleagues eliminates this issue," said Stella Batalama, Ph.D., dean, College of Engineering and Computer Science. "This novel technology offers a platform where the sperm cells experience different shear stress in different parts of the chip, which facilitates the isolation of competent sperm cells without impacting their integrity."

In the United States, an estimated 15 percent of couples have trouble conceiving. Globally, approximately 48.5 million couples experience infertility. According to the U.S. Centers for Disease Control and Prevention, 12 percent of women of childbearing age have used an infertility service. All treatment costs for infertility can range from $5,000 to $73,000. The average patient goes through two IVF cycles, bringing the total cost of this procedure, including medications, between $40,000 and $60,000. An estimated 85 percent of IVF costs are often paid out-of- pocket.

More information: Sandhya Sharma et al, Selection of healthy sperm based on positive rheotaxis using a microfluidic device, *The Analyst* (2022). DOI: 10.1039/d1an02311j

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