Copper Intrauterine Device (IUD) [1]

By: Higginbotham, Victoria Keywords: birth control [2] IUD [3] copper IUD [4]

The copper intrauterine device, or IUD, is a long-term, reversible contraceptive first introduced by Howard Tatum and Jamie Zipper in 1967. Health care providers place an IUD inside a woman's uterus [5] to prevent pregnancy [6]. Copper IUDs are typically made of T-shaped plastic with some portion covered with exposed copper. Prior to the invention of the first IUDs, women had few long-term options for safe and reliable birth control [7]. Those options mostly consisted of barrier methods and the oral birth control [7] pill, which were only effective if used correctly and consistently. For women seeking to control their fertility, a copper IUD was one of the first forms of long-term birth control [7] that was highly effective and did not require consistent and regular action on the woman's part to remain effective.

Copper IUDs prevent pregnancy [6] by disrupting the process of conception [8], which is when the male sperm [9] and the female egg [10] come together to form a fertilized zygote [11]. Conception can only occur after a woman's body releases an egg [10] from one of her ovaries in a process called ovulation [12], which happens every twenty-eight days. The egg [10] travels through the woman's fallopian tubes [13] and enters the uterus [5]. If a woman has sex during the period of ovulation [12], the egg [10] may be fertilized by the sperm [9]. If the egg [10] gets fertilized, it may implant onto the wall of the uterus [5] and develop into a fetus [14]. If the egg [10] does not get fertilized, it leaves the uterus [5] during the woman's menstrual period.

Prior to the invention of the IUD, there were fewer reliable ways for women to prevent pregnancy [6]. According to Judy Norsigian, co-author of *Our Bodies, Ourselves*, birth control [7] allowed women to choose if and when they became pregnant, which gave women more opportunity to pursue their education, aspirations, and create more equal relationships with men. In 1909, Richard Richter, a physician from Germany, developed one of the first IUDs, although his did not use copper. Richter's device was a small ring of coarse silk worm gut that was capped with celluloid, a type thin of plastic. Richter's IUD never became popular, but research into IUDs to prevent pregnancy [6] continued.

In 1929, Ernst Gräfenburg, a physician living in Germany, improved Richter's IUD design. Gräfenburg's design, which he called the Gräfenburg Ring, was a coiled ring of silver wire wrapped with silk thread. Gräfenburg reported that his silver ring IUD was successful in preventing pregnancy [6], with only 1.6 percent of users becoming pregnant while using it. Researchers later discovered that the silver wire in Gräfenburg's IUD contained twenty-six percent copper. However, the researchers did not note the contribution of copper to the effectiveness of IUDs at that time. Following Gräfenburg's success, researchers developed various other types of IUDs throughout the early twentieth century. Most were plastic with variations in shape that included rings, coils, trapezoids, and T shapes.

Howard Tatum and Jamie Zipper developed the first copper-bearing IUD in 1967. Tatum and Zipper were both affiliated with the Population Council, an organization [15] that provided grants and funding for research on developing safe and effective birth control [7]. In 1967, Tatum worked at the Council's Center for Biomedical Research, where he developed a T-shaped plastic IUD, a design he incorporated into the first copper IUD. Tatum's device had a T-shape to better conform to the shape of the uterus [5]. The T-shape also reduced some side effects associated with ring-shaped IUDs, such as pain and bleeding. However, Tatum's device did not become an effective means of birth control [7] until his colleague Zipper suggested the addition of copper.

In 1968, Zipper, a former biomedical fellow of the Population Council, was conducting research in Chile. Through his work, Zipper showed that intrauterine copper reduced the risk of pregnancy [6] in rabbits. Tatum and Zipper combined their ideas to create the first copper IUD, and named it the Copper T 200, or TCu 200. The Copper T 200 was a plastic T-shaped device with copper wire coiled along the vertical shaft.

In 1970, the Population Council formed the International Committee for Contraception Research, or ICCR, a coalition of experts in reproductive medicine. The ICCR began clinical trials to test the safety and efficacy of the Copper T 200 IUD. In 1976, the US Food and Drug Administration [16] approved the Copper T 200 for use in the US. According to the Population Council, by 1992 the Copper IUD was the most popular method of birth control [7] world-wide, as 90 million women used it.

Copper-bearing IUDs work in several ways to prevent pregnancy [6]. The first mechanism of action is the foreign body response. A foreign object in the uterus [5] elicits a local inflammatory response. That local inflammatory response can cause the destruction of sperm [9] by the leukocytes, or white blood cells, from the woman's immune system. The immune response targets all foreign cells, including sperm [9], which prevents any embryos from forming or implanting in the uterus [5]. That mechanism of action is

common among all IUD types. The inflammatory response, which IUDs use to prevent pregnancy [6], increases with the size of the IUD. However, because copper IUDs work by mechanisms other than just device size as well, they can be smaller yet still as effective as larger non-copper IUDs.

Copper IUDs have added contraceptive effects due to the presence of copper ions. Copper ions are associated with an inflammatory response in the uterus [5], meaning sperm [9] cannot reach the egg [10] to fertilize it and create an embryo. Researchers also postulate that copper ions act on the cervical mucus at the opening of the uterus [5] to create a spermicidal, or sperm [9] killing, effect. To fertilize an egg [10], sperm [9] must first pass through cervical mucus before entering the uterus [5]. Copper ions decrease the sperm's ability to move and prevent the sperm [9] from passing through the cervical mucus and going on to fertilize the egg [10]. Additionally, some researchers have suggested that copper ions are deleterious to eggs as well as sperm [9], so even if a sperm [9] fertilizes an egg [10], the egg [10] itself may be impaired and unable to develop into an embryo. Due to those characteristics of copper and the small size of copper IUDs, women who have never been pregnant or have smaller uteri can use copper IUDs, expanding the contraceptive options available to them.

The process of inserting a copper IUD has remained largely the same since the IUD was first introduced. In 2018, a healthcare professional can place a copper IUD during a non-surgical procedure. The healthcare specialist places the copper IUD inside the uterus [5] through the vaginal canal. At that time, women may experience some discomfort in the form of cramping or pinching. According to the manufacturers of Paraguard, the most common copper IUD in the US, common side effects of the copper IUDs include cramping and heavier, longer periods. There is also an increased risk for pelvic inflammatory disease [17], or PID, a type of infection in the uterus [5]. Sometimes, IUDs are difficult to remove, as they become embedded in the uterus [5] and require surgical removal. In cases where the copper IUD fails to prevent a pregnancy [6], there is a five percent chance that the pregnancy [6] will be ectopic, or occurring outside of the uterus [5].

Modern copper IUDs look like earlier versions of the copper IUD. However, researchers have improved the design over time to increase efficacy and the duration of effectiveness. The effectiveness of a copper IUD is largely dependent upon the rate of dissolving of copper ions into the uterine environment. As the copper dissolves over time, the IUD becomes less effective as less copper is available. The first copper IUD introduced, the Copper T 200, could remain effective for three years. The device had coiled copper wire around the vertical shaft of the T-shaped device that dissolved over time, causing the IUD to become less and less effective.

In 1972, clinical trials began for the new IUD model, the Copper T 380, which had a greater copper content than previous copper IUDs. The new design increased the amount of time for which a copper IUD could remain effective. The Copper T 380 has additional copper collars or cylinders that coat both arms of the T and thicker wire with more copper wrapped around the vertical shaft. Due to the increased amount of copper in the device, the Copper T 380 remains effective for a minimum of six years. In 1980, the ICCR, worked with the Population Council to continue refinement of the the design of the copper IUD. The ICCR eliminated the use of wire and used copper collars on the arms and the vertical shaft of the T in the Copper T 380. That change in design increased the duration of effectiveness of the copper IUDs from six years to between ten and fifteen years.

Since the 1980s, higher doses of copper and a higher proportion of exposed copper have prolonged the effectiveness of copper IUDs. As of 2018, for women in the US, the copper IUD commonly available is the Copper T 380, which the FDA approved in 1984. ParaGard is the brand name for that IUD. Other countries have approved more types of copper IUDs in different shapes and sizes.

Copper IUDs and IUDs in general are highly effective. According to the manufacturers of ParaGard, the copper IUD is over nintey-nine percent effective. The efficacy of IUDs is high partly because IUDs do not rely on the user. The most widely used contraception [18] for women worldwide is the contraceptive pill. However, the efficacy of the pill and many other birth control [7] methods is dependent upon the user taking it correctly and consistently, which researchers call perfect use. Perfect use is rare, and as a result, nearly fifty percent of unintended pregnancies are due to contraceptive failure. While IUDs and the contraceptive pill have similar rates of protection from pregnancy [6] with perfect use, the failure rate is twenty times as high in women who use the pill compared to women who use a long acting method like the IUD. A copper IUD is a long-term reversible birth control [7], a method that maintains fertility while still allowing women to prevent pregnancies. A copper IUD can last for years without needing replacement, but it is not permanent. Once an IUD is removed, fertility often returns immediately. Other forms of long term birth control [7] include sterilization [19] through tubal ligation [20], which is when a woman's fallopian tubes [13] are non-reversibly severed or blocked to prevent conception [8]. Sterilization through tubal ligation [20] and the use of copper IUDs are considered equally as effective in preventing pregnancy [6], making copper IUDs a cost-effective alternative to sterilization [19] procedures.

In 2012, 5.5 percent of women who used contraception [18] used an IUD. That represented a marked decrease from the IUD's peak popularity in the 1970s, when nearly sixty percent of women using contraception [18] chose an IUD. According to the Population Council, the popularity of IUDs in general declined after one IUD, the Dalkon Shield [21], gained media attention and was associated with higher risks of infection and maternal death in women who became pregnant while using the device. The

Dalkon Shield [21] was recalled after three years on the market. Because of the difficulty of studying the exact mechanisms of birth control [7] in humans [22], research on the exact mechanism of the copper IUD is scarce. According to Maria Ortiz and Horacio Croxatto, that has led to the incorrect assertion that copper IUDs can kill embryos. That false assertion equates IUDs with early abortion [23] and would thus be prohibited by the Catholic Church. However, that assumption is not supported by empirical evidence. Rather, copper IUDs prevent the formation of embryos and cannot terminate an embryo.

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Subject

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Topic

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[3] https://embryo.asu.edu/keywords/iud
[4] https://embryo.asu.edu/keywords/copper-iud
[5] https://embryo.asu.edu/search?text=uterus
[6] https://embryo.asu.edu/search?text=pregnancy
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