Intrauterine Device

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***Abstract*—Intrauterine devices (IUDs) represent one of the most e active and safe long-acting reversible contraceptive methods available in modern reproductive health. This review article provides a comprehensive overview of intrauterine devices, including their historical development, types, mechanisms of action, advantages, disadvantages, and clinical applications. The contraceptive e activeness of IUDs is estimated at 99.2-99.9%, making them comparable to sterilization methods. This review examines two primary types of IUDs: non-hormonal copper-mediated devices and hormonal devices releasing levonorgestrel or progesterone. The copper IUD works through spermicidal action and in amatory response, while hormonal IUDs function by thickening cervical mucus, thinning the endometrium, and suppressing ovulation. Both types o er reversibility, cost-e activeness, and long-term protection ranging from 3 to 12 years. This article discusses the anatomical considerations for IUD placement, the menstrual cycle changes associated with IUD use, advantages including low maintenance and absence of systemic hormonal e acts, and potential disadvantages such as heavier menstrual bleeding and increased cramping. Additionally, modern applications of IUDs extend beyond contraception, including emergency contraception, treatment for heavy menstrual bleeding, and management of pelvic pain associated with endometriosis. The article concludes that IUDs remain a highly suitable option for women seeking e active, reversible, and long-term contraception, particularly those in stable relationships and without risk of sexually transmitted infections.**

***Index Terms*—Intrauterine Device (IUD), Copper-T, Levonorgestrel, Long-Acting Reversible Contraception (LARC), Contraceptive E cacy, Reproductive Health**

I. INTRODUCTION

The intrauterine device (IUD) is a small contraceptive device inserted into the uterus through the cervix to prevent pregnancy. It represents a major advancement in reproductive health, giving women a highly e active, reversible method of long-term contraception. A thin string attached to the IUD extends into the upper vaginal region, facilitating easy removal and allowing women to check for device placement. The contraceptive e activeness of IUDs is remarkable, estimated to be between 99.2% and 99.9%, making them one of the most effective contraceptive methods available globally

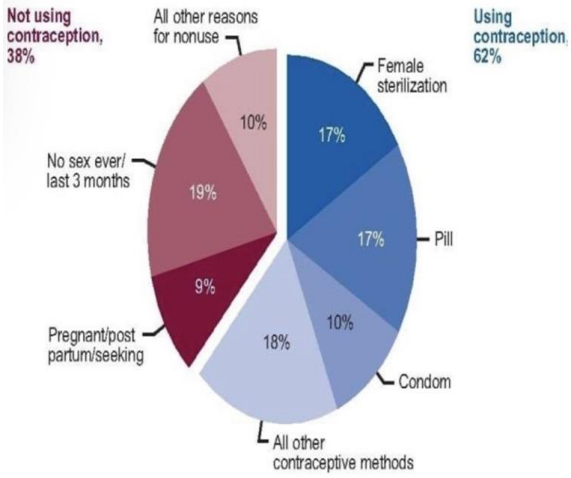


Table 1: Need Of Contraceptives

Method Of Contraception	% Of Those Served
Oral contraceptive pills	26.3
Condom or diaphragm	10.0
Intrauterine devices	6.4
Foam	2.6
Rhythm	2.2
Others	28.8

Historical Significance and Current Status

The history of IUDs dates back to the early 1900s, with initial designs using silkworm gut and metal wires. However, modern IUDs, particularly plastic-based devices introduced in the 1960s, have revolutionized contraceptive options. Dr. Jack Lippes' introduction of the Lippes Loop in 1962 marked a significant milestone, followed by the development of copper-mediated devices in the 1970s. The discovery of intrauterine copper's contraceptive properties by Dr. Jaime Zipper in 1969 expanded IUD effectiveness significantly.

Contemporary IUDs, including the Copper-T 380A (ParaGard) approved in 1984 and the levonorgestrel-releasing device (Mirena) approved in 2001, demonstrate exceptional safety and efficacy profiles.

II. IMPORTANCE IN REPRODUCTIVE HEALTH

Despite initial concerns and controversies, particularly related to the Dalkon Shield in the 1970s, IUDs have re-emerged as first-line contraceptive recommendations by major health organizations including the American College of Obstetricians and Gynecologists (ACOG), the World Health Organization (WHO), and the Centers for Disease Control and Prevention (CDC). The resurgence in IUD use, from 0.8% in 1995 to 7.2% between 2006-2014 in the United States, refracts growing recognition of their safety, efficacy, and reversibility.

Mechanism of Action Overview

While the precise mechanism of IUD action remains multifactorial, current understanding suggests that IUDs induce general biochemical and histological changes in the endometrium. Copper ions in non-hormonal IUDs contribute to sperm lytic and gametotoxic effects, reducing gamete viability and lowering fertilization chances. These ions impede sperm motility, capacitation, and survival. Conversely, hormone-releasing IUDs increase cervical mucus viscosity, preventing sperm entry into the cervix, and create an environment unfavorable for implantation through elevated progesterone and reduced estrogen levels.

III. SCOPE OF THIS REVIEW

This review article comprehensively examines intrauterine drug delivery systems (IUDDS), focusing on the various intrauterine techniques that have emerged as effective methods for site-specific controlled release drug delivery. The article discusses anatomical considerations, physiological changes during the menstrual cycle, advantages and disadvantages of IUDs, different types of devices available, mechanisms of action, clinical applications beyond contraception, and development history. By synthesizing current research and clinical evidence, this review aims to provide pharmacy students and healthcare professionals with thorough knowledge of IUDs, enabling them to counsel patients effectively and support evidence-based decision-making in reproductive health

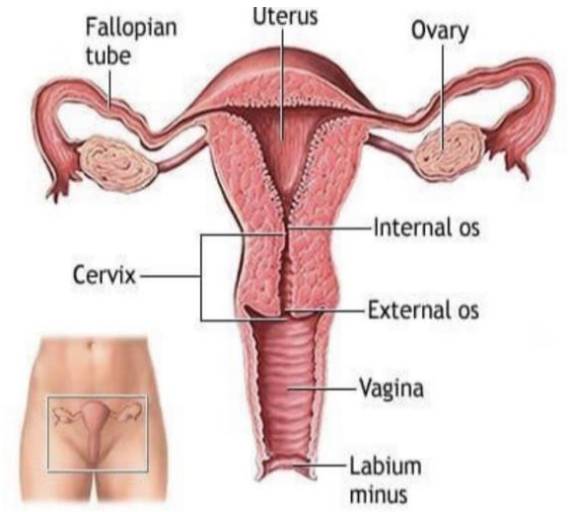
IV. MAIN CONTENT STRUCTURE

The article systematically covers the following key topics:

1. Anatomy of the Uterus and Prerequisites for IUD Placement
2. Menstrual Cycle Physiology and IUD-Induced Changes
3. Types of Intrauterine Devices: Copper-Mediated and Hormonal
4. Mechanisms of Contraceptive Action
5. Clinical Advantages and Disadvantages
6. Modern Applications and Therapeutic Uses
7. Comparative Effectiveness and Safety Profile
8. Contraindications and Patient Selection
9. Historical Development and Evolution of IUD Technology
10. Future Perspactives in Intrauterine Drug Delivery

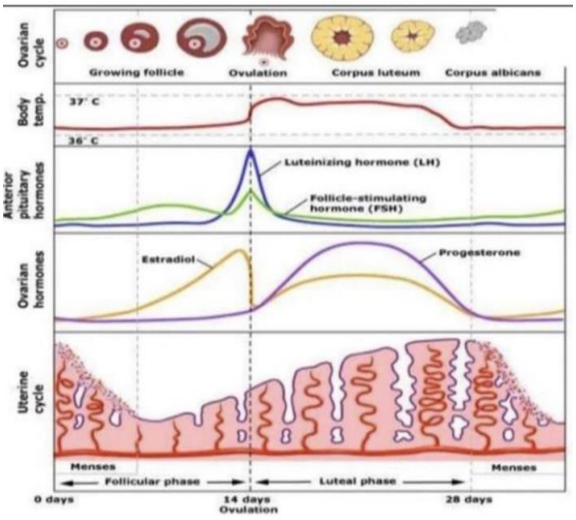
V. ANATOMICAL CONSIDERATIONS

Understanding uterine anatomy is crucial for successful IUD placement and function. The uterus is a pear-shaped, muscular organ measuring approximately 3 inches in length and 2 inches in width. The T-shaped IUD design accommodates the triangular shape of the uterine cavity, preventing displacement and expulsion. The endometrium, consisting of three layers (stratum functional is, stratum basalis, and connective tissue), interacts directly with the IUD, producing the biochemical changes necessary for contraceptive efficacy.



VI. PHYSIOLOGICAL INTERACTIONS

IUDs interact with multiple physiological systems. The foreign body presence stimulates endometrial inflammatory responses, affecting sperm survival and embryo development. Hormonal IUDs release medication directly into the uterine cavity, achieving high local concentrations while minimizing systemic absorption, thereby reducing side e acts compared to oral contraceptives



VII. ADVANTAGES OF INTRAUTERINE DEVICES

- Highly e active in preventing pregnancy (99.2-99.9% e cacy)
- Cost-e active and inexpensive compared to daily medications
- Non-coital dependent – does not interrupt sexual activity
- Requires no partner involvement or cooperation
- Long-term protection: 3-10 years depending on device type
- Suitable for emergency contraception (copper IUD within 5 days of unprotected intercourse)
- Convenient – eliminates need for daily pill adherence
- Does not disturb natural hormonal cycles (copper IUD)
- Reduced user-related errors compared to user-dependent methods
- Hormone-releasing IUD bene cial for heavy menstrual bleeding
- May reduce risk of endometrial cancer
- Easily reversible upon removal with return to fertility
- Suitable for breastfeeding women

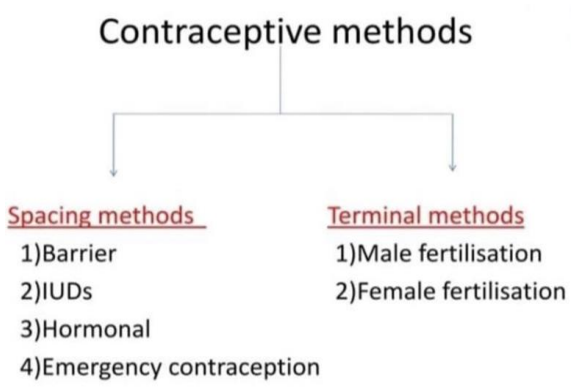
No impact on milk production or breastfeeding safety

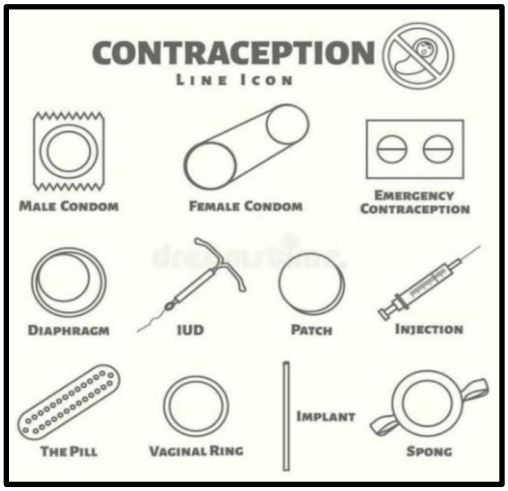
VIII. DISADVANTAGES AND CONTRAINDICATIONS

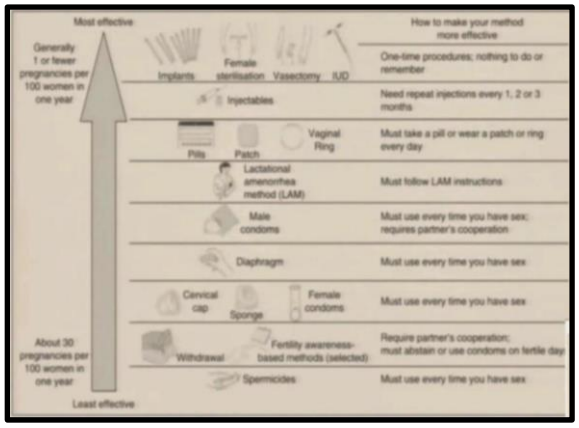
- Does not protect against sexually transmitted infections (STIs) or HIV/AIDS
- May increase likelihood of pelvic in amatory disease if STI acquired
- Potential for increased ectopic pregnancy risk if conception occurs
- Can cause heavier and more painful periods (especially copper IUD)
- Cramping and discomfort during and 24-48 hours after insertion
- Rare but serious complications: uterine perforation (1/1000 cases)
- Device expulsion: 2-10% of IUDs expelled, especially in rst months
- May cause irregular spotting between periods
- Requires skilled healthcare provider for insertion and removal
- Contraindicated in current pregnancy or pelvic infection
- Relative contraindications in women with abnormal uterine anatomy

- Higher bleeding risk in women with bleeding disorders
- Not recommended in women with untreated STIs
- Hormonal IUD contraindicated in women with breast cancer history

IX. TYPES OF INTRAUTERINE DEVICES

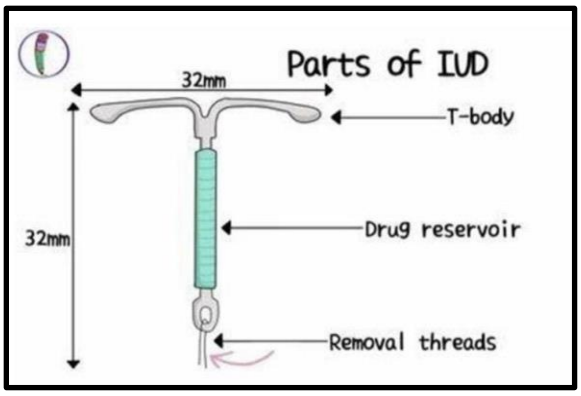






Non-Hormonal (Copper-Mediated) IUDs

Copper IUDs are constructed with polypropylene or polyethylene plastic frames with fixed quantities of copper wire wound around the device. The T-shaped design ensures optimal positioning and contact with the endometrium, maximizing contraceptive efficacy.



Copper-T Devices

Cu-T-200: Approved by the FDA in 1976, this device features copper wire with a surface area of 200 mm² and maintains physical integrity for 15-20 years

Cu-T-220C: A newer variant with 5 solid copper sleeves on the vertical arm and 2 on the horizontal arm, providing 220 mm² of copper surface area. Estimated effectiveness period exceeds 20 years with reduced pregnancy and expulsion rates

Cu-T-380A (ParaGard): FDA-approved in 1984, this device contains 380 mm² of copper and barium sulphate (making it radiopaque). It provides contraceptive protection for 10-12 years and demonstrates superior e cacy when copper wire contacts the upper uterine cavity.

X. MULTI-LOAD COPPER IUDS

MLCu-250: Combines features of Cu-T and Daikon Shield designs, providing 3 years of protection. Pregnancy rate: 0.3%, Expulsion rate: 1% only.

MLCu-375: Features thicker copper wire (375 mm² surface area), available in standard and short lengths, providing 5 years of protection Copper Release Kinetics

Copper IUDs function through continuous ionization and chelation processes. Release rates typically follow linear kinetics, with Cu-7-284 delivering approximately 9.87 µg/day.

Corrosion and encrustation layers of protein and calcium form over time, gradually

reducing copper release rates but maintaining contraceptive effectiveness.

XI. HORMONAL IUDS

Hormonal IUDs release progestin directly into the uterine cavity, achieving high local concentrations while minimizing systemic effects.

Progesterone-Releasing IUD

This device contains microcrystalline progesterone in silicon oil with barium sulphate, releasing 65 mcg/day. It requires yearly replacement but offers advantages including: Increased e activeness compared to non-hormonal IUDs Reduced menstrual blood ow Decreased dysmenorrhea. Lower rates of device-related bleeding and pain

Dose [mcg/day	% Pregnancy
10	5.2
25	2.7
65	1.1
120	0.6

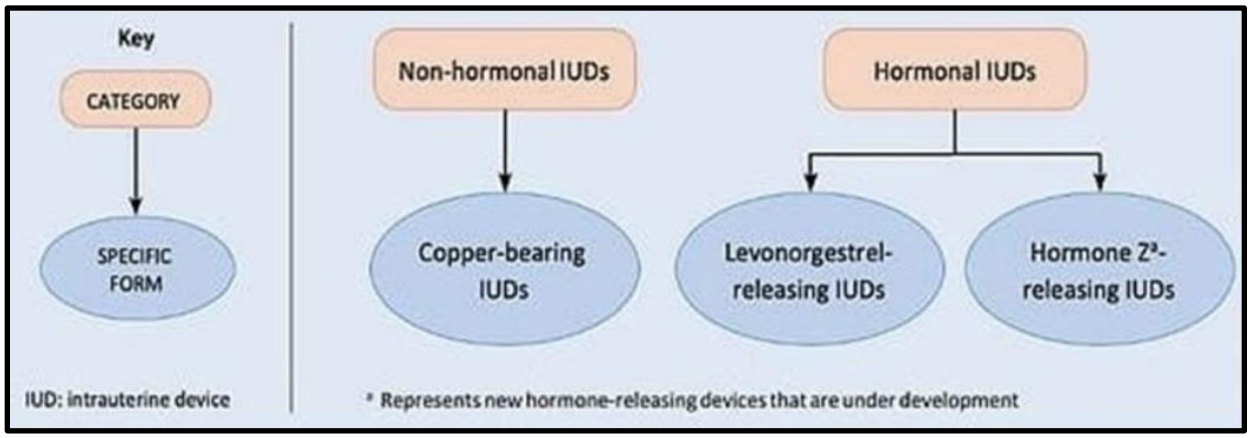
XII. LEVONORGESTREL IUD (MIRENA)

The Mirena IUD features a polyethylene stem with a silicone elastomer core containing 52 mg levonorgestrel. It releases 20 mcg/day initially, then decreasing to 16 mcg/day, providing protection for 5 years. This device:

- Suppresses endometrium and ovulation in some women
- Prevents endometrial proliferation
- Thickens cervical mucus for additional contraceptive action
- Demonstrates Pearl pregnancy rate of 0.0-0.2 per 100 women-years

Clinical effectiveness data demonstrates that contraceptive efficacy is directly related to daily progesterone release, with efficacy improving from 94.8% (10 mcg/day) to 99.4% (120 mcg/day).

XIII. MECHANISMS OF CONTRACEPTIVE ACTION



XIV. NON-HORMONAL (COPPER) MECHANISM

Copper's contraceptive action involves multiple mechanisms:

- Cytotoxic effect at high concentrations
- Spermatocide and sperm to-depressive action
- Competitive inhibition of steroid-receptor interaction sites
- Prevention of 17-β-estradiol binding to endometrial cytosol
- Minimal e act on sperm motility but profound e acts on viability
- Blastocystocidal activity (toxic to early embryos)
- Foreign body in amatory response stimulation
- Altered endometrial histology unfavorable for implantation

The copper concentration in endometrial epithelium and super cial stroma directly inhibits steroid binding

to their receptors, amplifying the contraceptive effect Hormonal Mechanism

XV. HORMONAL IUDS FUNCTION THROUGH:

- Increased cervical mucus viscosity preventing sperm entry
- Endometrial suppression and gland atrophy
- Prevention of normal endometrial development required for implantation
- Ovulation suppression (in some users with Mirena)
- Altered endometrial morphology unfavorable for blastocyst implantation
- Decidual reaction changes eliminating conditions for pregnancy
- High local hormone concentrations with minimal systemic absorption
- Progestational changes in endometrial tissue

XVI. CLINICAL APPLICATIONS BEYOND CONTRACEPTION

Emergency Contraception
The copper IUD (ParaGard) can be inserted within 5 days of unprotected intercourse, providing pregnancy prevention with over 99% e cacy. This application makes it ideal for emergency situations and represents a non-hormonal emergency contraceptive option.
Management of Heavy Menstrual Bleeding
The Mirena IUD signi cantly reduces menstrual blood loss and is employed therapeutically for menorrhagia. Comparative studies demonstrate superior e cacy of Mirena compared to oral progesterone medications. It serves as a viable alternative to hysterectomy in severe menorrhagia cases, improving quality of life while preserving fertility.

Menopausal Hormone Therapy
Mirena provides an alternative route for progesterone administration in combined hormone replacement therapy. It produces similar reductions in hot ashes and night sweats as conventional oral/patch HRT, bene ting women who experience oral medication challenges.

Pelvic Pain Management
Mirena reduces pelvic pain associated with endometriosis through local endometrial suppression and systemic anti-in ammatory e acts, o ering therapeutic bene t beyond contraception.

XVII. SAFETY AND EFFICACY COMPARISON

Comparative Effectiveness Data

Method	Effectiveness	Duration
Cu-T-380A (ParaGard)	99.2-99.9%	10-12 years
Mirena (Levonorgestrel IUD)	99.0-99.9%	5 years
Cu-T-220C	99.8%	20 years
Oral Contraceptive Pills	91% (typical use)	Continuous
Condom	85-98% (varies)	Single use
Sterilization (Tubal Ligation)	99.5%	Permanent

Table 1: Comparative Contraceptive E activeness of IUDs versus Other Methods

Methods of contraception	Pregnancies	Births	Deaths			MBR[Mortality Benefit Ratio]
			P	M	Total	
None	60,000	50,000	12	0.0	12.0	
Condom or diaphragm	13,000	10,833	2.5	0.0	2.5	0.664
Oral pills	100	83	0.0	3.0	3.-0	0.060
IUDs	2190	1825	0.44	0.3	0.74	0.015

The Guttmacher Institute data indicates that IUD use increased from 2.0% in 2002 to 7.7% in 2009, reacting increasing acceptance and recognition of IUD safety and efficacy

Side Effect
Copper IUD Side Effects:

- Menstrual changes (heavier, longer periods in 12% of users)

- Increased cramping, especially first months
- Spotting between periods
- Expulsion (2-10% of cases)
- Perforation (1/1000 cases, usually at insertion)
- Anemia (in predisposed women)
- Vaginal discharge
- Pain during intercourse (rare)

Hormonal IUD Side Effects:

- Ovarian cysts (usually regress spontaneously)
- Breast tenderness
- Mood changes
- Headaches
- Irregular bleeding pattern initially
- Decreased menstrual ow (beneficial for some)

XVIII. CONTRAINDICATIONS AND PATIENT SELECTION

Absolute Contraindications

- Current pregnancy
- Active pelvic infection or recent septic abortion
- Unexplained vaginal bleeding
- Anatomically abnormal uterus

Known or suspected pregnancy Relative Contraindications
For All IUDs:

- Current STI or multiple sexual partners without barrier protection
- Undiagnosed abnormal vaginal bleeding
- Immunocompromised state (HIV with CD4 <200 cells/mm³)
- Anatomical abnormalities limiting IUD placement

For Copper IUD:

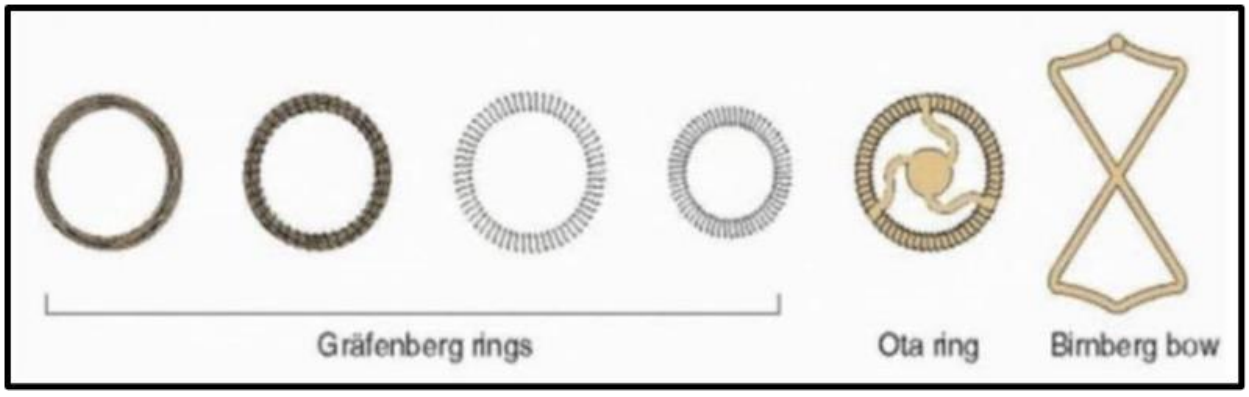
- Heavy or prolonged menstrual periods
- Severe dysmenorrhea
- Iron deficiency anemia
- Endometriosis
- Wilson's disease

For Hormonal IUD:

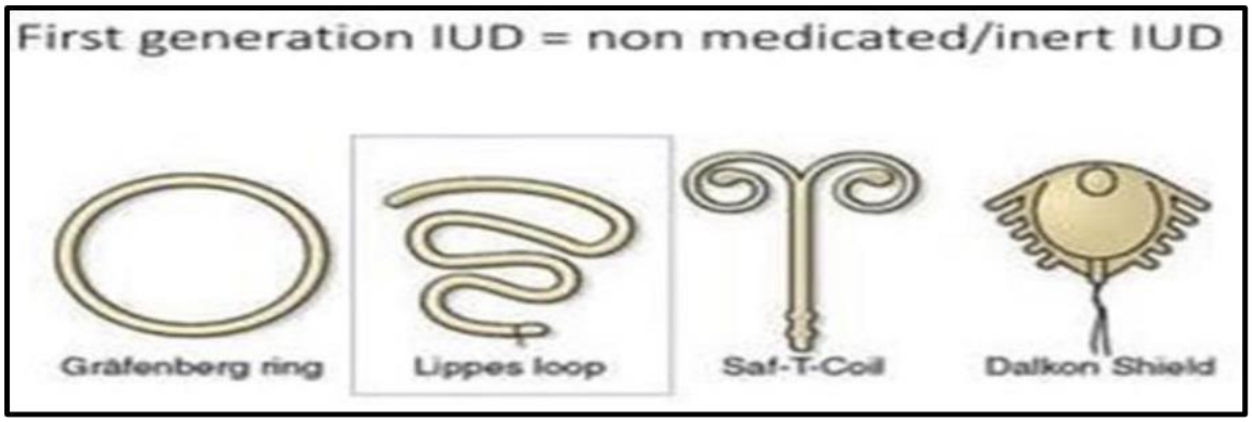
- History of breast cancer (relative)
- Severe liver disease
- Current or recent thromboembolism

XIX. HISTORICAL DEVELOPMENT AND EVOLUTION

Early History (1900s-1940s)
The history of IUDs begins in the early 20th century, with Dr. Richard Richter proposing silkworm gut rings in 1909. Karl Prust and Ernest Graefenberg developed similar designs in the 1920s, with Graefenberg's ring demonstrating a 3% pregnancy rate.



Modern IUD Era (1960s-1980s)
Dr. Lazar Margulies' polyethylene device (1960) and Dr. Jack Lippes' Loop (1962) revolutionized IUD technology. Dr. Jaime Zipper's discovery of copper's contraceptive properties (1969) led to copper-medicated devices, while Dr. Howard Tatum's T-shaped plastic device addressed comfort issues



Contemporary Developments (1988-Present)

The FDA approval of Copper-T 380A (1984), progesterone IUD (1970s-2000s), and Mirena (2001) established modern IUD options. The FDA approval of Skyla (2013) provided a lower- hormone alternative for nulliparous women.

XX. CONCLUSION

The intrauterine device represents one of the most e active, safe, and reversible contraceptive methods available in modern reproductive health. With efficacy rates of 99.2- 99.9%, IUDs rival surgical sterilization while maintaining reversibility and allowing rapid return to fertility upon removal. The development of multiple IUD types from non-hormonal copper devices to various hormonal formulations provides options suitable for diverse patient populations and clinical scenarios. Beyond contraception, IUDs serve important therapeutic roles in managing heavy menstrual bleeding, treating endometriosis-associated pain, and providing emergency contraception. The historical evolution from early silk-based devices to contemporary plastic and hormonal systems demonstrates substantial technological advancement and increased safety profile.

The resurgence in IUD popularity, driven by evidence-based medicine and expanded indications, re acts appropriate clinical recognition of their benefits. For women seeking e active, long term, reversible contraception without daily adherence requirements, IUDs remain an excellent choice, particularly those in stable relationships and without STI risk.

Pharmacy professionals must possess comprehensive knowledge of IUD mechanisms, types, advantages, disadvantages, and applications to counsel patients e actively and support shared decision-making in reproductive health. As the pharmaceutical eld expands intrauterine drug delivery applications beyond contraception, understanding IUDDS becomes increasingly important for contemporary pharmacy practice.

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