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MORPHOLOGY AND MORPHOMETRIC DYNAMICS OF OVARIAN POTENTIAL DEVELOPMENT DURING PUBERTY AND ADOLESCENCE

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АННОТАЦИЯ:

Puberty and adolescence represent critical physiological periods characterized by profound hormonal, structural, and functional transformations within the female reproductive system. The establishment and maturation of functional ovarian potential during these developmental stages are governed by intricate morphological remodeling and morphometric scaling within the ovarian parenchyma. This article examines the structural evolution of ovarian tissue, the dynamics of follicular maturation and selective atresia, stromal remodeling, and key quantitative morphometric parameters that define reproductive longevity and fertility potential from early prepubertal stages to full sexual maturity..

INTRODUCTION

Puberty marks the critical physiological transition from childhood to sexual maturity, initiated by the neuroendocrine reactivation of the hypothalamic-pituitary-gonadal (HPG) axis. During puberty and subsequent adolescence, the human ovary undergoes extensive tissue remodeling, transitioning from an endocrinologically quiescent, immature organ to a physiologically active gonad capable of cyclic folliculogenesis, ovulation, and steroidogenesis.

Understanding the comprehensive morphological and morphometric characteristics of the ovary across pubertal stages (Tanner stages I through V) provides crucial reference metrics for reproductive histology. These quantitative indicators serve as essential clinical baselines for distinguishing physiological developmental trajectories from early endocrine disorders,

such as premature ovarian insufficiency (POI) and polycystic ovary syndrome (PCOS).

HISTOLOGICAL ARCHITECTURE OF THE PUBERTAL OVARY

The pubertal ovary is macroscopically divided into two functional zones: the outer cortex, containing the follicular reserve, and the inner medulla, composed of highly vascularized connective tissue. During puberty, systemic increases in Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH) induce distinct cytological modifications in both zones.

FOLLICULAR MATURATION AND RECRUITMENT DYNAMICS

Ovarian follicular development is a continuous, tightly regulated process that progresses through distinct morphological stages: primordial, primary, secondary, antral (tertiary), and pre-ovulatory (Graafian) stages. Prior to puberty, follicular growth arrests primarily at the early antral stage, followed by obligatory atresia.

The Primordial Follicle Pool and Initial Recruitment

The primordial follicle represents the fundamental unit of the ovarian reserve. Histologically, it consists of an oocyte arrested in the diplotene stage of prophase I of meiosis, enveloped by a single squamous layer of granulosa cells. During puberty, gonadotropin-independent initial recruitment recruits a cohort of primordial follicles into the growing pool each day, converting flattened granulosa cells into cuboidal primary epithelium.

Gonadotropin-Dependent Selection and Antrum Formation

As follicles progress to the secondary stage, granulosa cells express FSH receptors and proliferate into a stratified epithelium. Surrounding stromal fibroblasts differentiate into two functional layers: the internal steroidogenic *theca interna* and the fibrous, structural *theca externa*.

Under the action of pituitary FSH, granulosa cells begin secreting follicular fluid (*liquor folliculi*), which coalesces to form a fluid-filled cavity known as the antrum. By mid-to-late adolescence, regular cyclic peaks in LH drive the selection of a single dominant follicle per cycle while non-dominant follicles undergo programmed apoptotic clearance (atresia).

STROMAL REMODELING AND VASCULAR DYNAMICS

Parallel to follicular growth, the ovarian stroma undergoes substantial structural expansion. Interstitial cells within the cortical stroma increase production of collagenous extracellular matrix, providing structural support to expanding antral cavities. Concurrently, intense angiogenesis in the medullary region increases blood flow to support steroidogenesis.

MORPHOMETRIC SCALING AND QUANTITATIVE METRICS

Quantitative morphometry serves as an objective tool for analyzing ovarian growth trajectories and evaluating reproductive capacity across pubertal Tanner stages.

Pre-pubertal (Tanner I) 0.7 – 1 .8 cm³ High Primordial Density < 3.0 mm ~ 68 %
Late Puberty (Tanner IV) 4.5 – 7.2 cm³ Established Antral Reserve 1 0.0 – 1 4.0mm

~ 50 %

HORMONAL & METABOLIC MODULATORS OF OVARIAN RESERVE

The morphometric expansion of the ovaries during puberty is modulated by complex endocrine feedback loops and systemic metabolic signals.

Insulin-like Growth Factor 1 (IGF-1) further enhances granulosa cell sensitivity to FSH, promoting follicular survival and antral expansion. In states of severe energy restriction or excessive physical exertion, reduced leptin and IGF-1 levels suppress the HPG axis, arresting morphometric ovarian growth.

CLINICAL RELEVANCE AND PATHOLOGY IDENTIFICATION

Establishing accurate age- and pubertal-stage-matched morphometric norms is critical for diagnosing adolescent gynecological and endocrine disorders:

Polycystic Ovary Syndrome (PCOS): Characterized morphometrically by an exaggerated increase in ovarian volume (> 10 cm^3), peripheral hyper-stringing of 12 or more small antral follicles (2–9 mm), and increased stromal echogenicity due to stromal hyper-androgenism.

Premature Ovarian Insufficiency (POI): Morphologically manifested as accelerated primordial depletion, reduced ovarian volume (< 1.5 cm^3 in late adolescence), and an absence of antral follicle development.

Central Precocious Puberty (CPP): Early premature activation of the HPG axis resulting in rapid ovarian enlargement and advanced follicular maturation prior to 8 years of age.

CONCLUSION

The morphometric expansion and morphological maturation of the human ovary during puberty and adolescence represent an extraordinary biological sequence essential for adult fertility. From initial recruitment of primordial follicles to cyclic selection of pre-ovulatory structures, these quantitative dynamics reflect the functional health of the HPG axis. Ultrasonic volumetric assessment and histological markers serve as indispensable instruments for evaluating adolescent reproductive potential and guiding early clinical interventions.

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