Introduction

Uterine cervical cancer is a common gynecological malignancy and a frequent cause of death, it is considered the third most common malignancy affecting the female genital tract in middle age group between 45 and 55 years, and its incidence is increasing rapidly in developing countries ***(Mahaja et al., 2013)***.

Diagnosis of uterine cervical carcinoma is suspected according to symptoms, results of clinical examinations, positive screening cytology results and its confirmation with biopsy ***(Moore, 2016)***, it is important to assess the extent of the disease before planning surgical treatment or chemo–radio therapy ***(Kinkel, 2016).***

Early stage disease is treated with surgery or chemo-radiotherapy and has a good prognosis. However, around 30% of all patients treated for uterine cervical carcinoma develop progressive or recurrent tumors ***(Lucas et al., 2015)***.

MRI has an excellent soft-tissue contrast resolution, which exceeds that of CT scanning and ultrasonography (US). Consequently, MRI is significantly more valuable than CT and US in the assessment of the size of the tumor,

the depth of the cervical invasion, and the loco regional extent of the disease (direct invasion of the parametrium, pelvic sidewall, bladder, or rectum ***(Saksouk, 2015).***

Magnetic resonance imaging (MRI) complements the clinical examination and is the optimal imaging method for evaluating the spread of uterine cervical cancer, it helps to select more accurately the most appropriate treatment approach.

MRI images visualize the uterine cervical tumor, its spread to adjacent tissues and organs and metastasis in the lymphatic nodes more early.

MRI examination methodology is also useful for assessing the efficiency of radiation or chemo-therapy and in the determination of tumor recurrence ***(Blleyguier et al., 2011).***

T2-weighted (T2W) imaging is the reference sequence for uterine cervical cancer staging, and recently DWI has been added to pelvic MRI protocols to increase diagnostic accuracy in tumor staging. This technique is a functional tool that relies on tissue water displacement to create a contrasted image ***(Lucas et al., 2015).***

The apparent diffusion coefficient (ADC) map provides useful information about the effectiveness of the

therapy as well as differentiation between malignant and normal tissue, and is also needed to reduce image misinterpretation, for example due to the T2 shine-through effect ***(Sala et al., 2010).***

Malignant uterine cervical cancer tissue demonstrates restricted diffusion and hence reduced ADC values when compared to normal tissue. DWI and ADC maps allow differentiation of benign from malignant zones of uterine cervix with high sensitivity and specificity ***(Chen et al., 2011).***

Aim of the Work

The aim of this study is to assess the role of Diffusion Weighed MRI in the assessment of uterine cervical cancer post therapy.

Anatomy of the Uterine Cervix

A. Topography:

The uterine cervix is the lower constricted segment of the uterus measuring approximately 3 to 4 cm in length ***(Skandalakis et al., 2004).***

It is conical in shape, with its truncated apex directed downward and backward. Owing to its relationships, it is less freely movable than the uterine body, so that the latter may bend on it ***(Gray, 2001).***

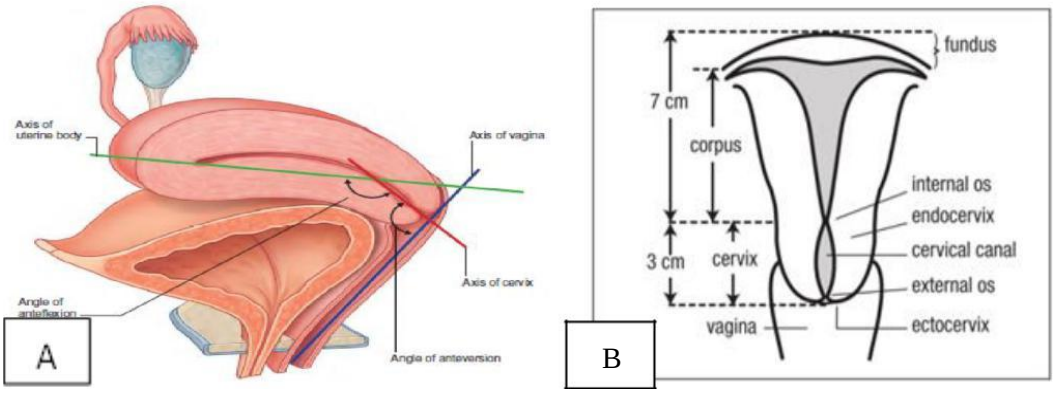

Fig. (1): Angles of ante-flexion and ante-version of Uterus and cervix **(**A) & (B**)** of a woman of reproductive age ***(Gray, 2001).***

The uterine cervix is separated from the upper part, or corpus, by the internal os separating this fibrous cervix from the muscular corpus ***(Albert et al., 2006).***

The lower end of the uterine cervix bulges through the anterior wall of the vagina, and is referred to as the vaginal

portion of cervix (or ectocervix) while the rest of the cervix above the vagina is called the supravaginal portion of cervix ***(Gray, 2001).*** They are approximately the same length according to ***(Albert et al., 2006).***

The vaginal mucosa is reflected around the front, back and sides of the cervix, thereby forming the vaginal fornices ***(Albert et al., 2006).***

The ectocervix has a convex, elliptical surface and is divided into anterior and posterior lips ***(Blaustein et al., 2002).***

The uterine cervix has an inner mucosal layer, a thick layer of smooth muscle, and posteriorly the supravaginal portion has a serosal covering consisting of connective tissue and overlying peritoneum ***(Gray, 2001).***

The passage between the uterine cavity and the vagina is via the endocervical canal, which is continuous with the endometrial cavity above at the level of the internal os and with the vagina below at the external os ***(Albert et al., 2006).***

B. Dynamic Epithelium anatomy

The mucosal lining of the uterine cervical canal is known as the endocervix and the mucosa covering the ectocervix is known as the exocervix ***(Ovalle et al., 2013).***

The endocervical mucosa is about 3 mm thick, lined with a single layer of columnar mucous cells ***(Susan, 2008).***

And in contrast, the exocervix is covered with non-keratinized stratified squamous epithelium which resembles the squamous epithelium lining the vagina ***(Gray, 2001).***

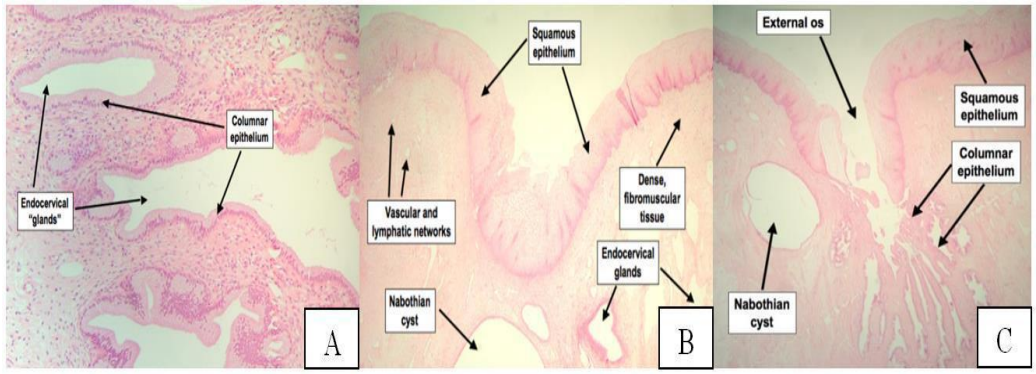

Fig. (2): **(A)** Lining of the endocervix: Medium power H&E showing the columnar-lined endocervical "glands". These are the same cells that line the endocervix ***(HistoQuarterly, 2016).***

(B) Lining of the cervix, near the external os: showing the ***HistoQuarterly, 2016).***

(C) Squamous columnar junction ***(Beckmann et al., 2013).***

The junction between these two types of epithelia is called the squamous columnar junction (SCJ) ***(Beckmann***

et al., 2013), and According to ***(Klüner et al., 2007)*** it is situated at the level of the external os.

C. The stroma

The wall of the uterine cervix is primarily made up of firm connective tissue. In contrast to the uterine corpus, the muscular portion accounts for less than 10% of the cervical wall and primarily consists of smooth muscle cells in circular arrangement ***(Klüner et al., 2007).***

D. Parametrium:

The Parametrium is the connective tissue between the leaves of the broad ligament. Medially, it abuts the uterus, cervix, and proximal vagina. Laterally, it extends to the pelvic side wall. Inferiorly, it is contiguous with the cardinal ligament. The Parametrium consists primarily of fat, especially in their lateral portions near the pelvic side wall through which run uterine vessels, nerves, fibrous tissues, and lymphatic vessels.

The distal ureters are in the Parametrium as they pass from the pelvic side wall to the bladder crossing the uterine arteries approximately 2 cm lateral to the margin of the cervix ***(Pannu et al., 2001).***

E. Relations of the uterine cervix :

1. The Supravaginal Part

Anteriorly, the supravaginal portion of the uterine cervix is separated from the bladder by a distinct layer of connective tissue (Parametrium), which also extends to the sides of the cervix and laterally between the layers of the broad ligaments. The uterine arteries are contained within this tissue and on each side of the cervix, the ureter runs downwards and forwards within the Parametrium at a distance of about 2 cm from the uterine cervix.

Posteriorly, the supravaginal cervix is covered with peritoneum that continues down over the posterior vaginal wall to be reflected on to the rectum, so forming the rectouterine pouch or pouch of Douglas ***(Albert et al., 2006).***

2. Vaginal part

The **vaginal portion** of the uterine cervix projects free into the anterior wall of the vagina between the anterior and posterior fornices. On its rounded extremity is a small circular aperture, the external orifice of the uterus, through which the cavity of the uterine cervix communicates with that of the vagina ***(Gray, 2001).***

F. Support:

A total of eight ligaments contribute to the support of the uterus. Diagnostically, which primarily pertains to the evaluation of the local extent of uterine cervical cancer, the vesico-uterine and the sacrouterine ligaments are most important ***(Klüner et al., 2007).***

The uterus is partially supported by three pairs of ligaments:

1. Anteriorly, the supravaginal cervix is suspended from the posterior aspects of the pubic bone by fibers of the pubocervical ligament.
2. The uterosacral ligaments are recto-uterine folds and contain fibrous tissue condensations of endopelvic fascia that arise from the posterior wall of the uterus at the level of the internal cervical os. They are continuous with the fibrous tissue around the lower parts of the ureters and pelvic blood vessels.
3. The paired cardinal (Mackenrodt's) or transverse cervical ligaments arise from the anterior and posterior marginal walls of the cervix and fan out laterally to insert into the fascia overlying the obturator muscles and the levator ani muscles. The cardinal and

uterosacral ligament complex is collectively called the Parametrium.

4. The peritoneum travels downwards to the pelvic cavity after covering anterior and posterior uterine surfaces. Two spaces are formed: the deep recto uterine space of Douglas and the shallow vesicouterine space ***(Gray, 2001).***

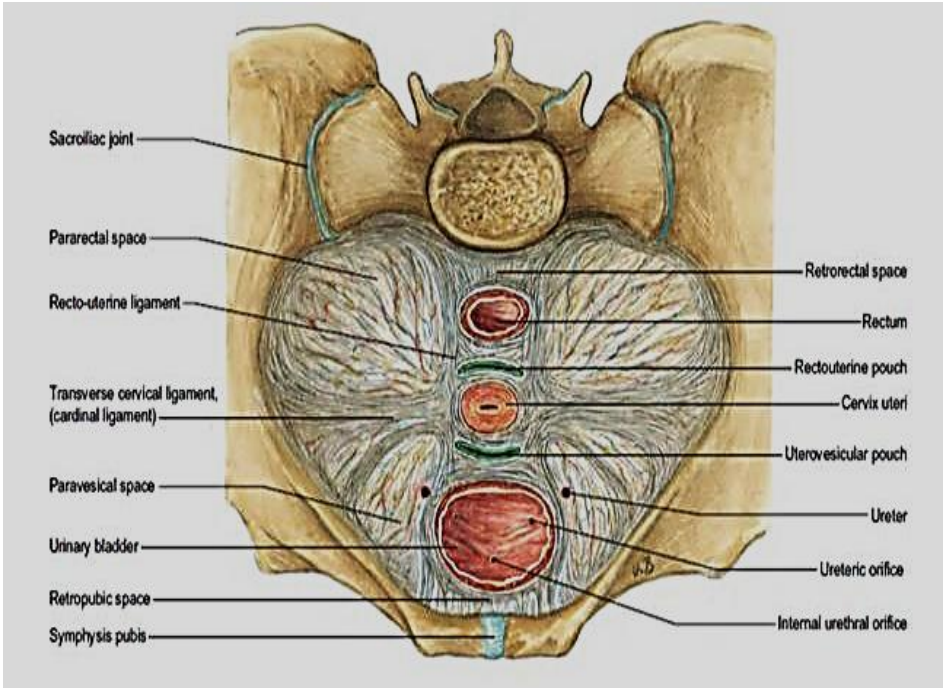

Fig. (3): Supporting ligaments of the pelvis showing the transverse cervical ligaments ***(Gray, 2001).***

G. Blood supply of the uterus and cervix:

1. Arteries

The main supply to the uterus is through the uterine artery this arises as a branch of the anterior division of the internal iliac artery. From its origin, the uterine artery crosses the ureter anteriorly in the broad ligament before branching as it reaches the uterus at the level of the cervico-uterine junction where it gives the branch that descends to supply the uterine cervix and anastomoses with branches of the vaginal artery to form two median longitudinal vessels, the azygos arteries of the vagina, which descend anterior and posterior to the vagina ***(Daftary, 2011).***

2. Veins

The uterine veins extend laterally in the broad ligaments, running adjacent to the arteries and passing over the ureters. They drain into the internal iliac veins. The uterine venous plexus anastomoses with the vaginal and ovarian venous plexuses ***(Gray, 2001).***

H. Lymphatic drainage of the cervix:

There are three lymphatic pathways of drainage for the cervix through which tumor can spread ***Table 1 (Pannu et al., 2001).***

Table (1): Lymphatic pathways of spread of uterine cervical cancer ***(Pannu et al., 2001).***

Lateral rout	*Hypo-gastric rout*	*Pre-sacral rout*
Medial chain of External Iliac LNs	Internal iliac vessel branches	Along utero sacral ligament
Middle and lateral chain of external iliac LN	Junctional LNs	Pre sacral lymphatic plexus
Common iliac LNs & para aortic LNs	Common iliac LNs & para aortic LNs	Common iliac LNs

All three routes lead to the common iliac lymph nodes, from where tumor can spread to the para-aortic lymph nodes ***(Ellis, 2011).***

I. Normal MR anatomy of the Uterine Cervix:

In contrast to the uterine corpus, the uterine cervix shows only little variation of its zonal anatomy as depicted by MRI with age, phase of the menstrual cycle, hormone replacement therapy, or use of oral contraceptive pills ***(Klüner et al., 2007).***

T2WI of normal uterine cervix:

The normal zonal anatomy of the cervix is well visible on high-resolution T2-weighted images. It is possible to distinguish four different anatomic zones: the endocervix, the inner stroma and the outer stroma.

1. Central hyperintense mucus/secretions in canal
2. Intermediate signal intensity endocervical mucosa and glands (contains numerous folds and clefts as the plicae palmate). Combined thickness of zones 1 and 2 is 2 to 3 mm, this layer is seen contiguous with endometrium
3. Low signal intensity endocervical fibrous stroma is 3 to 8-mm thick, it is seen contiguous with the junctional zone.
4. Intermediate signal intensity outer loose stroma, ***(Manfredi et al., 2015).***

The differing signal intensities are attributed to differing nuclear / cytoplasmic ratios. The endocervical canal contains mucus glands and secretions, and is visualized as a high signal stripe of variable thickness **(Fig.4a)** ***(Hoad et al., 2005).***

Fig. (4a): Normal uterine cervix on sagittal T2WI. (a) Sagittal plane .The four major zones are very well depicted on T2W images. High signal intensity endocervical canal (blue arrow-head), intermediate signal intensity Plicae palmatae (white arrow), low signal intensity fibrous stroma (black arrow) and intermediate signal intensity outer smooth muscle (black arrow-head) ***(Hriack et al., 2015).***