A PROSPECTIVE STUDY OF THE VALUE OF PRE- AND POST-TREATMENT MAGNETIC RESONANCE IMAGING EXAMINATIONS FOR ADVANCED CERVICAL CANCER

CSABA CSUTAK[1], CLAUDIA ORDEANU[2], VIORICA MAGDALENA NAGY[2], DIANA CRISTINA POP[2], SORANA DANIELA BOLBOACA[3], RADU BADEA[4], LILIANA CHIOREAN[4], SORIN MARIAN DUDEA[1]

[1]Department of Radiology, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania
[2]Institute of Oncology Prof. Dr. Ion Chiricuta, Cluj-Napoca, Romania
[3]Department of Medical Informatics and Biostatistics, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania
[4]Department of Medical Imaging, Iuliu Haţieganu University of Medicine and Pharmacy, Institute of Octavian Fodor Gastroenterology and Hepatology, Cluj-Napoca, Romania

Abstract

Background and aim. Cervical cancer has high incidence and mortality in developing countries. It is the only gynecological malignancy that is clinically staged. Staging at the time of diagnosis is crucial for treatment planning. After radiation therapy, clinical examination is limited because of radiation changes. An imaging method relatively unaffected by radiation changes would be useful for the assessment of therapy results and for management.

We sought to demonstrate the value of magnetic resonance imaging (MRI) in the pre- and post-treatment assessment of cervical cancer.

Methods. This was a prospective study, carried out between November 2012 and October 2014 on 18 subjects with advanced-stage cervical cancer diagnosed by colposcopy. The disease stage was determined clinically according to the International Federation of Gynecology and Obstetrics (FIGO) criteria. Only patients with disease stage ≥ IIB or IIA with one of the tumor dimensions > 4 cm were enrolled in the study. All patients underwent abdominal-pelvic contrast-enhanced MRI as part of the workup. Tumor size, local invasion, involved pelvic lymph nodes, and staging according to MRI criteria were evaluated. Clinical and MRI examinations were also performed after chemoradiotherapy. After chemoradiotherapy, 94% of the patients (17 of 18) were treated surgically.

Results. Eighteen patients aged 32–67 met the inclusion criteria and were enrolled: 10 stage IIB, 6 stage IIIA, 1 stage IIA and 1 stage IIIB, according to clinical staging. Using histopathological findings as a reference, MRI staging accuracy was 83.3%. The concordance of the clinical stage with MRI stage at the first examination was 56%. Parametrial involvement was assessed on pretreatment and post-treatment MRI, with post-treatment MRI compared with histology. There was no statistically significant difference between the pre- and post-therapy gynecological examinations (GYN) and the corresponding MRI assessments as to tumor size measurements (p>0.05). The post-therapy restoration of the cervical stroma ruled out tumor recurrence.

Conclusions. For a detailed characterization of loco-regional extension, the calculation of tumor volume, and the evaluation of distant metastatic changes, clinical examination is insufficient. Magnetic resonance imaging is helpful aftertherapy.

Background and aim

Cervical cancer ranks second worldwide among female malignant tumors [1]. The incidence of this disease is 42.7 per 100,000 in Eastern Africa, 5.8 per 100,000 in Western Asia, while Eastern European countries are in the middle third of the ranking, with an incidence of 14.5 per 100,000 [1]. In 2012 in Europe the incidence of cervical cancer was 24.2 per 100,000 women, and the mortality was 12.2 per 100,000 women, with Romania ranking first [2]. The majority of newly diagnosed cases are locally advanced (parametrial invasion) [3].

To date, cervical cancer is the only gynecological malignancy that is still staged clinically, according to the FIGO (International Federation of Gynecology and Obstetrics) criteria introduced in 1958, updated and revised in 2009 [4]. However, because of the persistent inaccuracy of imaging modalities in this disease, and the low availability of cross-sectional imaging in developing countries, clinical examination has maintained its primacy to provide a uniform, practical and reliable staging between different centers and countries [5].

The disease prognosis depends on factors that are not included in the FIGO staging, such as tumor volume and the presence of adenopathy [6,7]. Correct staging is essential for subsequent therapeutic management. Advanced stages are treated by chemoradiotherapy, while early stages are treated surgically [4]. Early stages can be graded clinically by the degree of invasion of the upper vagina [4]. For advanced stages (parametrial invasion), there is a risk of understaging using clinical examination alone [7].

Magnetic resonance imaging (MRI) examination is widely accepted for the characterization of cervical cancer, for the detection of parametrial and pelvic wall invasion, and for detection of adenopathy [8]. Post-chemoradiotherapy MRI examination allows the measurement of the residual tumor volume and the visualization of the restored cervical stroma.

The aim of this study was to evaluate the use of pre- and post-therapy MRI for advanced-stage cervical cancer with large tumors > 4 cm, parametrial and pelvic sidewall extension, and bladder and rectal involvement.

Methods

A prospective study was carried out from November 2012 to October 2014 in subjects with advanced-stage cervical cancer diagnosed by colposcopy at the Oncology Institute. Ethical approval for the study was obtained from the Institutional Ethics Committee. Informed consent was obtained from all patients.

Inclusion criteria were a clinical examination (GYN) performed by a radiotherapist (C.O.) specializing in gynecologic oncology, blinded to any MRI information, to establish the tumor stage according to the FIGO criteria [4], and tumor size (in the lateral [lat] or anteroposterior [AP] dimension). The patients included in the study had cervical cancer stage ≥ IIB or IIA with one of the tumor dimensions > 4 cm. Exclusion criteria were lack of consent to participate. After the clinical examination, all patients included in the study underwent abdominal-pelvic MRI with intravenous contrast agent. MRI examinations were performed with a 1.5 T scanner (General Electric Sigma Excite®, GE Medical Systems, Milwaukee WI, USA). For pelvic imaging, a phased-array coil was used, and the following sequences were performed: axial T1 FSE (TE/TR, MIM FULL/700 msec; FOV, 40/42 cm; section thickness, 6 mm; spacing, 1 mm; NEX, 2); sagittal T2 FRFSE (TE/TR, 85/3100; FOV, 24 cm; section thickness, 5 mm; spacing, 0.5 mm; NEX, 4); oblique axial T2 FRFSE (TE/TR, 102/3350; FOV, 26 cm; section thickness, 5 mm; spacing, 0 mm; NEX, 3); axial T2 FRFSE (TE/TR, 80/3000; FOV, 40/42 cm; section thickness, 6 mm; spacing, 1 mm; NEX, 3); axial diffusion-weighted imaging (DWI) with b values of 800/1000 mm²/s.

For abdominal examination, a phased-array coil was used, and the following sequences were performed: axial 2D FIESTA (TE/TR 1.6/3.7; flip angle, 75°; FOV, 40/42 cm; section thickness, 6 mm; spacing, 1 mm; NEX, 1; performed with breath hold), coronal 2D FIESTA (TE/TR 1.6/3.7; flip angle, 75°; FOV, 40/42 cm; section thickness, 6 mm; spacing, 1 mm; NEX, 1; performed with breath hold), axial T2 FRFSE with FAT SAT (TE/TR 90/2020 FOV, 40/42; section thickness, 6 mm; spacing, 1 mm; performed with breath hold), axial T1 FSPGR FAT SAT (TE/TR, IN PHASE 4.2/210; flip angle, 80°; FOV, 40/42 cm; section thickness, 6 mm; spacing, 1 mm; NEX,1; performed with breath hold).

After 18–20 s following intravenous injection of gadolinium dimeglumine (Magnevist®, Berlex, Wayne NJ, USA) 0.1 mol/L per kg body weight, a LAVA 3D sequence (flip angle, 12; FOV, 40/42 cm; section thickness, 4.4 mm; spacing, 0) was performed in the abdomen, and an axial T1 FSPGR with fat sat sequence (TE/TR, IN PHASE 4.2/210; flip angle, 80°; FOV, 40/42 cm; slice thickness, 6 mm;

spacing, 1 mm; NEX,1; performed with breath hold) was performed in the abdomen. Pelvic post-contrast imaging was acquired 5 minutes after intravenous injection with axial T1 FSE (TE/TR, MIM FULL/700 msec; FOV, 40/42 cm; section thickness, 6 mm; spacing, 1 mm; NEX, 2) images.

The patients underwent chemoradiotherapy based on clinical examination. The second clinical evaluation was performed 3–4 months after completion of chemoradiotherapy with clinical re-assessment and measurement of the residual tumor measurements in the two axes. A second abdomino-pelvic MRI examination with intravenous contrast agent using the same protocol was performed within one week of the second clinical examination. The results of both pre- and post-therapy MRI examinations were assessed by the same radiologist (Cs.Cs.) with 5 years of experience in pelvic oncology, blinded to the clinical stage, who established the tumor stage, measured the tumor size in three dimensions (lat = laterolateral, AP = anteroposterior, and CC = craniocaudal]), calculated the tumor volume, and monitored the tumor evolution post-therapy. The tumor volume was calculated according to the ellipsoid formula:

$$V = D1 \times D2 \times D3 \times \frac{\pi}{6} \qquad (1)$$

where V = volume, D_1 = lat dimension, D_2 = AP dimension, D_3 = CC dimension.

Image analysis criteria (MRI stage): Cervical cancer appeared as a hyperintense mass on T2-weighted images (T2WI). In stage IIA the cervical tumor invades the upper two-thirds of the vagina, without parametrial involvement. The sagittal T2WI showed a hyperintense mass that protruded into the upper vagina, disrupting the hypointense vaginal wall. In stage IIB the tumor invaded the parametrium. Oblique axial T2WI showed a disruption in the hypointense ring of cervical stroma. In stage IIIA the tumor invades the lower third of the vagina. The sagittal T2WI showed a hyperintense mass protruding into the lower vagina, the hypointense vaginal wall being disrupted. In stage IIIB the cervical tumor extends to the pelvic wall and may produce hydronephrosis. Oblique axial T2WI displayed a hyperintense mass invading the parametrium and pelvic wall. Pelvic sidewall invasion is considered if the tumor extends to a distance of < 3 mm from the pelvic wall. In stage IVA the tumor invades the bladder or rectal mucosa. On axial, oblique axial and sagittal T2WI a disruption or segmental thickening of the hypointense bladder or rectal wall was seen. On axial T1WI (T1-weighted imaging) contrast enhancement was noted in the involved bladder or rectal wall. Distant metastases are stage IVB. On the contrast-enhanced abdomino-pelvic examination the abdominal metastases and lymph nodes were analyzed. The inclusion criteria for lymph node metastasis was a short axis measurement >1 cm. Imaging analysis of the cervical tumor was performed in accordance with the data described in the literature [8,9,10].

After chemoradiotherapy and MRI examination, the team of radiotherapists and surgeons decided on the indications for surgery in 17 patients. One case with distant metastases and urinary bladder and rectal invasion was not surgically treated.

The following were assessed: accuracy of MRI staging, clinical FIGO staging vs. MRI staging, parametrial involvement (pre-treatment MRI vs. post-treatment MRI, post-treatment MRI vs. pathology), the clinically evaluated tumor size with the MRI-measured tumor size pre- and post-therapy, tumor volume at diagnosis with tumor volume post-therapy, tumor volume with FIGO staging, and parametrial invasion. All tumors were assessed morphologically, with the analysis of endophytic (endometrial) development cases. The presence of adenopathy and the FIGO stages at which it occurred was determined. Restoration of the cervical stroma was evaluated post-treatment by MRI examination.

Statistical analysis: Quantitative variables are summarized as mean ± SD (standard deviation) whenever data proved normally distributed. Qualitative variables are presented as percentages and associated 95% confidence intervals (CI) with the value of confidence intervals computed using an exact method [11] and are given in square brackets. The comparisons between groups were done using a Student's *t*-test for independent samples for quantitative normally-distributed data and a Z test for proportions. The association between gynecologic examination (GYN) and MRI stage was assessed with the Pearson correlation coefficient. Statistical Software (v. 8) was used for statistical analysis. The results were considered statistically significant at p<0.05.

Results

Between November 2012 and October 2014, 18 patients aged between 32 and 67 years (mean 50.59±10.69) met the inclusion criteria and were analyzed. There were no demographic significant differences between included cases. Four out of 18 patients were under the age of 45 years (22.22% [5.86–49.69]). Histopathological diagnosis after biopsy identified squamous carcinoma in 15 (83%) patients, adenocarcinoma in two patients, and undifferentiated carcinoma in one patient.

The patients were classified clinically as stage IIB (10 patients, 56% [28.09–77.47]), stage IIIA (six patients, 33% [11.42–60.80]) and one case each of IIA and IIIB. A summary of the clinical examination findings (baseline and post-chemoradiotherapy) is presented in Table 1.

The accuracy of MRI examination for the staging of cervical cancer in the group of 18 patients with advanced stages was 83.3% compared with the pathological data. The pathological data were acquired from surgery performed after chemoradiotherapy, a method used in Asia, South America, and Eastern European countries.

Table I. Clinical characteristics.

Diameter	Baseline	Postradiotherapy	Statistics (p-value)
AP (mm)			
Min	10	0	
Mean±SD	36.94±15.82	6.78±10.14	$8.56\ (1.43 \cdot 10^{-7})$
Max	70	40	
lat (mm)			
Min	10	0	
Mean±SD	40.31±14.51	6.94±9.42	$11.80\ (1.30 \cdot 10^{-9})$
Max	70	35	

The agreement between GYN and MRI stage was 56% (95%CI [28.09-77.47]) (see Figure 1, Table 2).

The accuracy of parametrial invasion detection on MRI was assessed on the pretreatment and post-treatment examinations, comparing them with the pathological data (Figure 2a). There were 16 cases with parametrial infiltration diagnosed by baseline MRI, also seen on post-treatment MRI. On the pre-therapeutic MRI, parametrial infiltration was seen as hyperintense signal on T2WI (T2-weighted imaging), and on post-treatment MRI parametrial involvement appeared hypointense on T2WI in 14 cases and hyperintense in two cases. Fifteen patients with parametrial infiltration underwent surgery after chemoradiotherapy. On pathology, parametrial fibrous changes were found in 14 patients (Figure 2b). Parametrial tumoral infiltration was detected in one case. One case with distant metastases and urinary bladder and rectal invasion detected on MRI was not operated on.

No significant differences were identified between GYN and MRI measurements either on baseline or on post-chemoradiotherapy measurements (p>0.05; Figures 3 and 4).

Significant correlations in tumor diameters (AP = anteroposterior and lat = laterolateral) were obtained for:
• AP GYN baseline vs. AP MRI baseline: 0.6680 (p=0.0024);
• lat GYN baseline vs. lat MRI baseline: 0.8284 (p=0.00002).

On the first MRI examination the tumor size was measured in the three axes. The numbers of patients with: one or more dimension of the tumor >4 cm; endophytic (endometrial) tumor development; and tumors in which the craniocaudal dimension was the largest, were attained. In 10 patients, one or more of the tumor dimensions was >4 cm. Eleven tumors had endophytic development (Figure 5a), and, in 10 patients the CC dimension of the tumor was the largest of the three planes measured by MRI, eight of these having endophytic tumoral growth.

On MRI the presence of paraaortic and iliac adenopathy was analyzed. There was one case meeting the inclusion criteria (short axis >1 cm), with iliac adenopathy detected on pre-therapy and post-therapy MRI and on the pathologic examination.
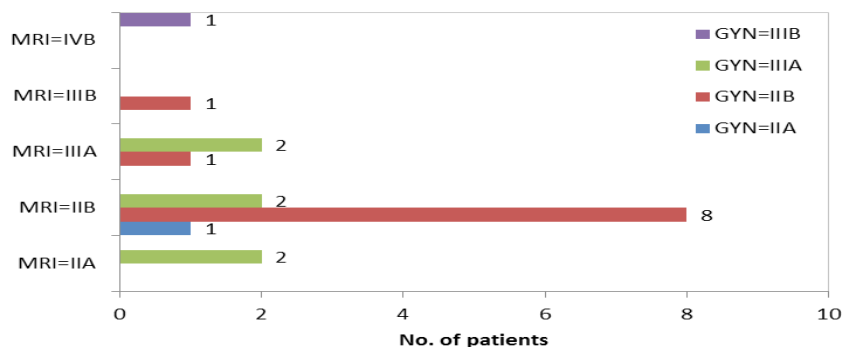
Figure 1. Concordance between GYN (gynecologist examination) stage and MRI stage.

Table II. GYN examination and relation with baseline MRI.

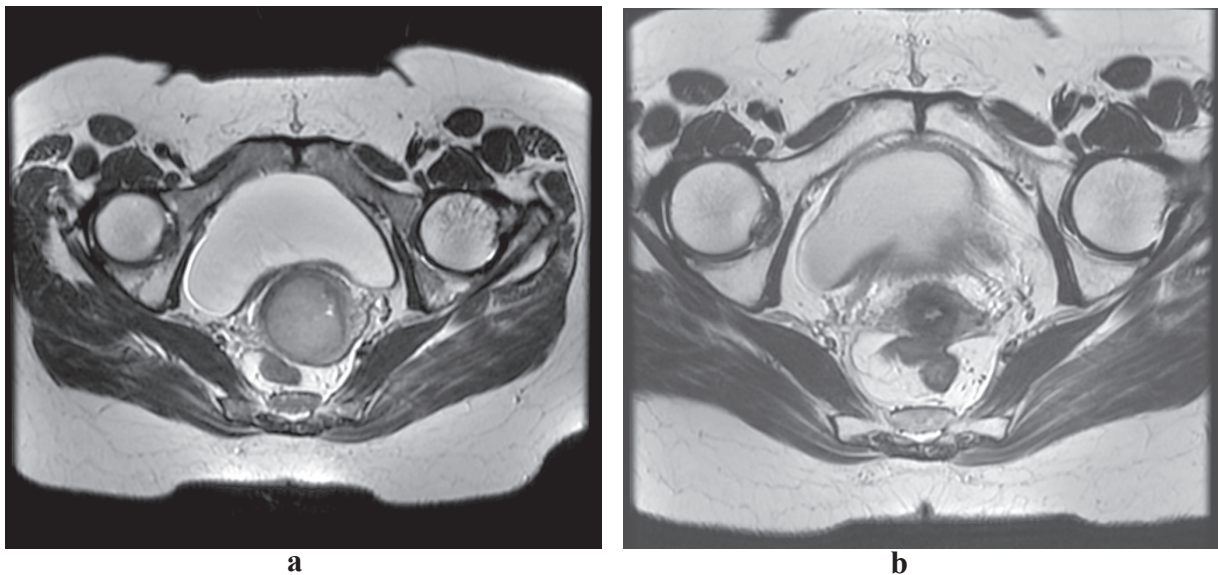| GYN	MRI-baseline	Iliac adenopathy	Lymph node hyperintense DWI	Distant metastasis
IIA	IIB	0	0	0
	IIB	0	2	0
	IIIA	0	0	0
IIB	IIIB	1	1	0
	IIA	0	1	0
	IIB	0	2	0
IIIA	IIIA	0	0	1
IIIB	IVB	0	1	0
Total		1 (5.56% [0.31–27.47])	7 (38.89% [16.98–66.36])	1 (5.56% [0.31–27.47])

Figure 2. A 49-year-old woman with cervical carcinoma staged as IIIA clinically and staged as IIB with MRI before treatment. Oblique axial T2-weighted MR image shows a cervical tumor with parametrial extension (a). Oblique axial T2-weghted MR image three months after therapy shows complete tumor regression, and restored hypointense cervical stroma. The parametrial extension post-therapy is replaced by fibrosis. (b).
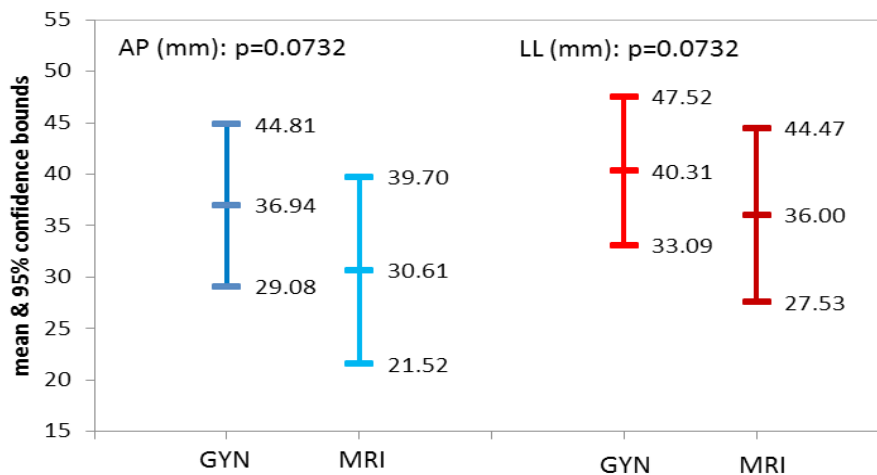

Figure 3. Comparisons between GYN and MRI tumor measurements: baseline.
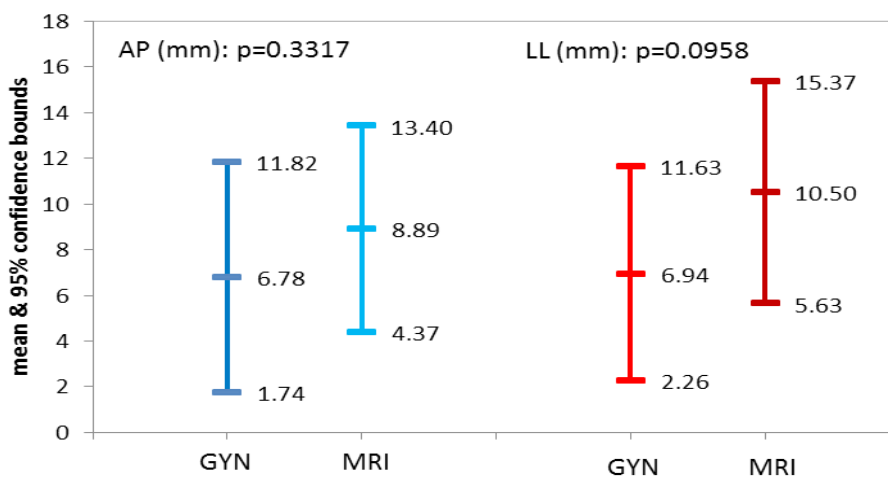

Figure 4. Comparisons between GYN and MRI tumor measurements: post-radiotherapy.

All MRI measurements of tumor size showed significantly decreased values in follow-up compared with baseline (p<0.001, Table 3). The greatest decrease in tumor size according to baseline MRI staging was observed in stage IIA (both cases, 100%), approximately 55% in stage IIB, and 33% in stage IIIA (Figure 6). AP and lat diameters showed similar behavior.

On post-chemoradiotherapy MRI, restoration of cervical stroma, with hypointense uninterrupted signal on the T2-weighted oblique axial sequence, was observed in 11 patients. In these patients pathology confirmed the absence of residual tumor (Figure 2b, Figure 5b). In six of these patients, the absence of tumor recurrence was clinically described and confirmed on pathology.

In the seven remaining patients, T2WI hyperintensity was observed in the cervix, and the cervical stroma was not completely restored. In five of these patients no residual tumor mass was found, while in two patients residual tumor was detected on MRI. Clinical examination detected post-therapy changes in the cervix in five cases, including the two patients with residual tumor. Histopathological examination found tumors limited to the cervix in three patients, while in three other cases, inflammatory changes and focal glandular hyperplasia were found.

Tumor volume determined by baseline MRI showed no significant correlation with either GYN/FIGO stage (Spearman rank correlation = 0.1994, p = 0.4277) or baseline MRI stage (Spearman rank correlation = −0.2274, p = 0.3641).

Tumor volume was significantly smaller (*t*-statistic = −6.45, p = 0.00013) in patients without bilateral parametrial invasion (0.03 ± 0.028 cm^3, 2 cases) than in those with bilateral parametrial invasion (31.69 ± 26.70 cm^3, 16 cases).
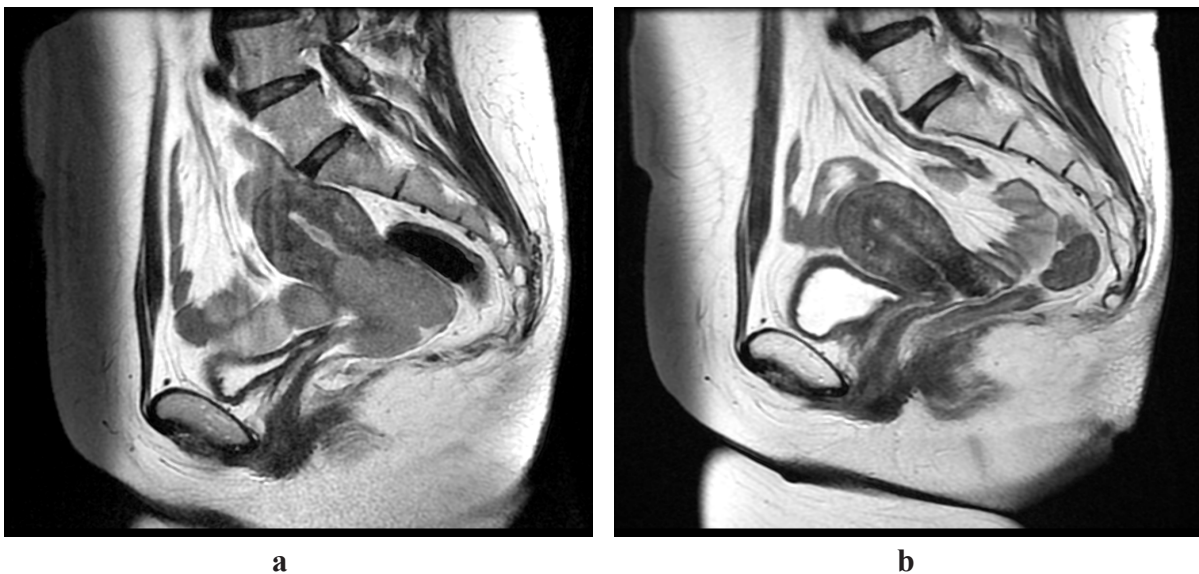

a   **b**

Figure 5. A 38-year-old woman with cervical carcinoma staged as IIB clinically and IIB with MRI before treatment. Sagittal T2-weighted MR image shows a bulky cervical tumor with endophytic (endometrial) extension (a). Sagittal T2-weghted MR image show complete tumor regression three month after therapy (b).

Table III. MRI evolution of tumor size.

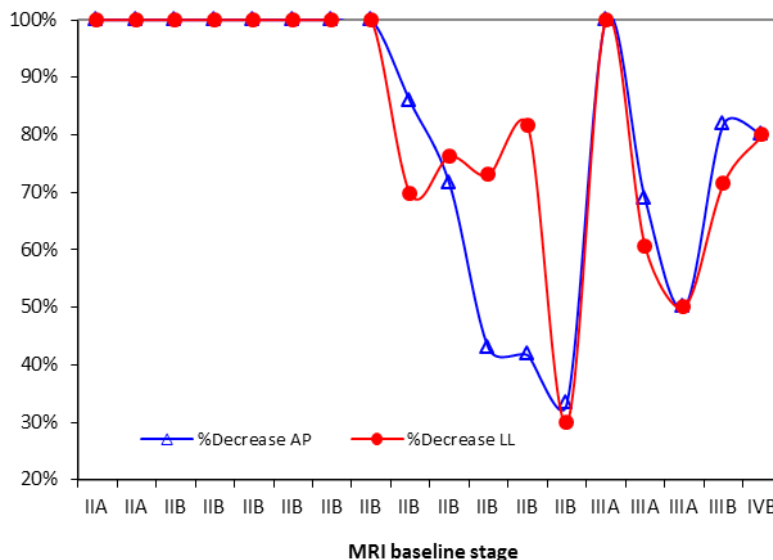|	Baseline	Post-radiotherapy	Statistics (p-value)
AP (mm)			
Min	3	3	
Mean ± SD	30.61±18.27	8.89±9.08	5.81 ($2.10 \cdot 10^{-5}$)
Max	60	35	
lat (mm)			
Min	3	3	
Mean ± SD	36.00±17.04	10.50±9.80	7.12 ($1.72 \cdot 10^{-6}$)
Max	70	35	
CC (mm)			
Min	3	3	
Mean ± SD	32.72±15.17	8.83±7.63	6.38 ($6.88 \cdot 10^{-6}$)
Max	53	30	
Volume-tumor (cm³)			
Min	0.01	0.01	
Mean ± SD	28.17±27.09	1.69±3.81	4.38 ($4.05 \cdot 10^{-4}$)
Max	78	14.04	

Figure 6. Decreasing post-treatment diameter (AP = anteroposterior and LL = lateral) according to MRI baseline staging.

Discussion

Literature focused on the staging of cervical cancer using 1.5 T. MRI has described an accuracy of 89.3% in [12] 75 patients, of 76% in a study of 67 patients [10], and 77% [13] in a study including 115 patients.

In three cases clinical examination underestimated the stage; it did not detect parametrial invasion in one, it did not detect pelvic wall invasion in a second, and in the third case it detected parametrial and pelvic wall invasions but did not detect bladder and rectal invasion and distant metastases. In these three clinically underestimated cases, the baseline MRI staging was good, and it could lead to a change of therapy. Contrary to literature data [14], two cases were overestimated by clinical examination, which described parametrial invasion, undetected by either pre- or post-treatment MRI or by postoperative pathology. In this study MRI underestimated two cases and overestimated one case, all involving invasion of the lower vagina. Still, these staging errors did not influence subsequent therapy. The use of intravenous contrast provided no additional information compared with T2 sequences, and may not be necessary [15].

The presence or absence of parametrial invasion is essential for further treatment planning, either with surgery or chemoradiotherapy [14]. Parametrial invasion has been assessed in this study on T2WI in an oblique axial plane. Published data from the early 1990s show MRI having 92% accuracy in detecting parametrial invasion as reported by Kim et al. [16], In this study, parametrial infiltration detected on pre-therapy MRI was compared with post-therapy MRI, with any positive MRI findings compared with pathology. The histopathological evaluation found fibrotic changes in the majority of cases, consistent with treated, previously viable tumor. As in previous studies, intravenous contrast did not prove useful for parametrial invasion detection [17].

The tumor stage and size at diagnosis are essential for the prognosis and subsequent management of patients [7]. The tumor diameter and the tumor volume measured by MRI on T2WI correlated with those found at pathology [18]. A study carried out by Subak et al. showed a 93% accuracy of MRI for determination of the tumor size, while the clinical examination accuracy was less than 60% [19]. In this study, the tumor size measured at diagnosis was slightly larger on clinical examination than the size measured by MRI, without statistically significant differences.

Hayashi et al. demonstrated that the most important factor for prognosis in tumors ≥ 4 cm is the CC measurement. McCarthy and Hricak showed in their study that the optimal therapy for a tumor > 4 cm is radiochemotherapy, even in the absence of parametrial invasion [20,21]. Most of the patients in the study had endophytic tumors, and in most of these, the largest dimension was in the CC direction. This measurement is impossible with GYN examination, indicating the role of MRI in treatment planning.

With excellent contrast between the tumor and the cervical stroma, MRI can accurately determine tumor volume [22]. Hricak et al. demonstrated that parametrial invasion is dependent on the tumor size [23]. Burghardt et al. reported that the probability of parametrial invasion depends on tumor size, so that if the tumor diameter is <2 cm, the probability of parametrial invasion is 6%; and if the tumor diameter is ≥ 2 cm, the probability of parametrial invasion increases to 28% [24]. In this study, the tumor volume proved to be significantly smaller in the two patients without parametrial invasion than in the rest of the

patients. Previous studies have demonstrated that tumor volume measured by MRI is a prognostic factor for the 5-year survival rate, which is reported to be 91% for tumors <2.5 cm³ and 70% for tumors measuring 10–50 cm³ [25].

Lymph node involvement in cervical cancer is also an important prognostic factor, although it is not included in the FIGO staging and does not change it [26]. The clinical diagnosis of adenopathy is difficult [27]. A study performed by Lanciano et al. reported 5-year survival rates for locally advanced cervical cancer of 57% in patients without adenopathy, 34% in patients with pelvic adenopathy, and 12% in those with paraaortic adenopathy [28]. The presence of pelvic adenopathy is considered to be of similar significance as pelvic wall invasion (stage III). The presence of paraaortic adenopathy is considered to be equal in risk to that of distant metastases (stage IV) [29]. Their presence requires a radical change of therapy [30]. This study used the accepted criterion for the diagnosis of adenopathy, which, is a short axis >1 cm [31]. In this study, iliac adenopathy was detected in one patient on pre- and post-therapy MRI, and was confirmed by histopathology. The MRI measurement of the detected adenopathy significantly decreased post-therapy.

Yong et al. demonstrated that the decrease of T2WI signal intensity and tumor volume 2–3 months post-radiotherapy indicates a good therapeutic response [32]. Vincens et al. reported that the radiotherapy response can be evaluated by the reduction of tumor volume, which should be analyzed no sooner than 2 months after therapy for an accurate measurement. Studying 44 patients with cervical cancer stages IB2/II 3–8 weeks post-chemoradiotherapy, they found a high percentage of false positives [33]. The reduction of tumor volume after chemoradiotherapy is important for subsequent therapy [34]. In this study, the patients had a statistically significant reduction of tumor dimensions after therapy, evident on both clinical and MRI examination. The dimensions measured by MRI after chemoradiotherapy were slightly larger than the clinically measured dimensions, without statistical differences. The volume measured by MRI was also statistically reduced between the pre- and post-therapy examination.

Hricak et al. demonstrated that the restoration of T2 hypointense cervical stroma is an indicator of a tumor-free cervix post-radiation [35]. In this study, more than half of the patients had restored cervical stroma after therapy, detected by MRI examination with histologic confirmation. Tumor recurrence needs to be considered if the cervical stroma is disrupted by areas of tissue hyperintensity on T2WI [36]. Not all of the cases with focally interrupted cervical stroma correlated with tumor recurrence at histology, it may represent persistent inflammatory changes post-therapy. The completely restored cervical stroma in the hyposignal gives certainty of a tumor-free cervix.

Post-therapy parametrial changes in patients with bilateral parametrial infiltration described on the first MRI examination appeared hypointense on T2WI. This corresponds with the Hricak et al. report that in the first 6 months post-radiotherapy, pelvic soft tissues in which tumor has been eradicated become hypointense on T2-WI, reflecting fibrosis. These post-radiotherapy changes can mimic tumor extension and parametrial invasion [37]. The majority of the patients in whom post-therapy MRI detected a bilateral low signal on T2WI (the opposite of a pre-treatment high signal) had no malignant parametrial changes according to pathology. This corresponds to the finding that T2 hyperintense areas pre-therapy undergo a change to hypointense signal on T2 if they have been successfully treated and are fibrotic, and that any hyperintensity on T2 post-treatment should be evaluated for residual tumor [38]. However, the false-negative findings in our one case show that this is not always accurate.

Conclusions

Clinical examination is of supreme importance in the evaluation of cervical tumors, with good results for assessment of loco-regional extension. For a detailed characterization of loco-regional extension, the calculation of tumor volume, and the evaluation of distant changes, the clinical examination is insufficient and MRI is required. The availability of MRI examination has increased over the past years. For tumor staging and locoregional extension, T2 sequences focused on the pelvis are useful in the majority of the cases, without the need for intravenous contrast, which reduces the costs of the examination. Because MRI is not included in the FIGO criteria, this examination is not requested by clinicians.

Post-therapy tumor evolution can be well assessed by MRI. Knowledge of the imaging appearance of the irradiated pelvis is key. The comparison of the pre- and post-radiation tumor volume is important for the prognosis of patients and subsequent therapeutic management. The protocol used is similar to that of the first examination, T2 sequences being essential, without the need for intravenous contrast agent administration.

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