Value of magnetic resonance imaging in predicting efficacy of GnRH analogue treatment for uterine leiomyoma

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BACKGROUND: Estimating pharmacological efficacy is important when selecting conservative treatment of uterine leiomyoma. Hence, the ability of magnetic resonance (MR) imaging to predict gonadotrophin-releasing hormone (GnRH) analogue efficacy was investigated. METHODS: A total of 85 lesions was studied in 40 patients who were clinically diagnosed as having uterine leiomyoma and treated with GnRH analogue for 24 weeks. To evaluate changes in lesion size, T2-weighted and gadopentetate-dimeglumine (Gd-DTPA)-enhanced, T1-weighted MR images were obtained within 2 weeks before, and immediately after termination of, GnRH analogue treatment. RESULTS: An average 46.3% size reduction was observed in 45 lesions (52.9%); these were seen as low signal intensity on T2-weighted images and enhanced by Gd-DTPA. Also, an average 44.7% size reduction was observed in lesions enhanced by Gd-DTPA, irrespective of signal intensity findings on T2-weighted images. The average size reduction of unenhanced lesions was only 17.8%, and significantly different from enhanced lesions ($P < 0.001$). The prediction of efficacy was difficult in those lesions not enhanced. CONCLUSIONS: It is considered that evaluation of MR signal intensities, and the presence or absence of Gd-DTPA enhancement, would predict treatment efficacy before GnRH analogue administration.

Key words: contrast-enhancement/GnRH analogue/MRI/myometrium/uterine leiomyoma

Introduction

Among tumours of the female genital tract, uterine leiomyoma has the highest incidence, with the lesion being found frequently during routine gynaecological examinations. Most treatments of uterine leiomyoma are managed surgically following a comprehensive diagnosis that includes clinical symptoms, and both physical and ultrasound findings. In developed countries, conservative management for the treatment of uterine leiomyoma has recently been preferred in order to retain the possibility of fertility when late childbirth, in combination with a late marriage, is considered.

It has been suggested that oestrogen is strongly linked with the development of uterine leiomyoma, and hence the suppression of oestrogen may offer the possibility of prohibiting the growth of uterine leiomyoma. The administration of a gonadotrophin-releasing hormone (GnRH), analogue which controls ovarian function by suppressing pituitary gonadotrophin secretion, has been considered effective as a conservative treatment of uterine endometriosis (Schriock et al., 1985). Thus, it is hoped that this might also apply to the conservative treatment of uterine leiomyoma, based on a similar pharmacological action (Maheux et al., 1987; Fujii, 1992).

Magnetic resonance (MR) imaging has non-invasive, reproducible and high-resolution diagnostic capability, and is valuable for differentiating uterine leiomyoma from uterine adenomyosis as it identifies both the location and number of uterine leiomyoma present (Togashi et al., 1988). The identification, diagnosis and histological characteristics of leiomyoma—as well as prediction of the degree of pharmacological efficacy—is important before any conservative treatment of uterine leiomyoma is carried out.

In the current study, MR imaging findings before and after GnRH analogue treatment of uterine leiomyoma were evaluated, and an assessment made as to whether it would be possible to predict the treatment efficacy of GnRH analogue using MR imaging.

Materials and methods

A total of 85 lesions was studied in 40 patients (mean age 40.3 ± 7.2 years; range 28–53) in whom uterine leiomyoma was diagnosed based on clinical symptoms and physical, ultrasound and MR imaging findings. Each patient received (s.c.) GnRH analogue (Leuplin® 3.75 mg; leuprorelin acetate, Takeda Chemical Industries, Ltd, Osaka,
Japan) on a total of six occasions, commencing on the second day of a menstruation, and at 4-week intervals.

A 1.5-T superconductive MR unit (Signa; GE Medical Systems, Milwaukee, WI, USA) was used for fast spin-echo T2-weighted imaging (TR/TE eff. 3000–5000/90–120 ms). The three largest uterine leiomyoma lesions in patients with multiple lesions, each ≥2 cm in its main diameter, were selected. The uterine leiomyoma volume was measured on MR images within 2 weeks of onset of GnRH analogue treatment and immediately after termination of treatment, using T2-weighted and 0.1 mmol/kg of gadopentetate dimeglumine (Gd-DTPA; Magnevist®, Japan Schering, Osaka, Japan) enhanced T1-weighted sequences. T2-weighted MR images were obtained on the sagittal and axial planes. The volume was calculated using the prolate ellipse equation, after which the ratio of volume reduction of the uterine leiomyoma was calculated for each patient. The effect of each lesion size reduction was evaluated using sagittal T2-weighted MR images, based on changes of volume by multiplying the maximum length of leiomyoma in the horizontal and vertical directions. Signal intensities of T2-weighted MR images were evaluated as either high, iso, or low, in comparison with that of the myometrium. With regard to the definition of Gd-DTPA enhancement, the degree of enhancement in the lesion was compared with that in normal uterine myometrium. Positive enhancement was considered to occur when the lesion was more strongly enhanced compared with normal myometrium; negative enhancement was considered to occur when the lesion was less enhanced compared with normal myometrium.

The MR images were read prospectively by two of the authors (I.I. and K.S.) who were aware only of the patient’s initial diagnosis. The location, size and appearance of the lesions were recorded, and the observers attempted to reach a consensus after careful assessment of serial images. MR images obtained before and after treatment were read separately and blindly. The inter-observer reliability (κ) was 0.81.

Suppression of ovarian function by GnRH analogue was assessed based on the sequential changes in serum oestradiol concentrations. GnRH analogue treatment was considered effective when serum oestradiol concentration was suppressed to <10 pg/ml after 8 weeks of administration, and the value was sustained until the end of the treatment period. All patients underwent effective ovarian suppression by GnRH analogue.

Data analysis
Data were expressed as mean ± SD, and analysed using an analysis of variance (ANOVA), Sheffé’s F-test, or the Kolmogorov–Smirnov two-sample test. A P-value < 0.05 was considered significant.

Results
Typical MR imaging findings of uterine leiomyoma before GnRH analogue treatment are shown in Figure 1, while the incidence of each MR imaging finding pattern is shown in Table I. The most frequently observed pattern (45 lesions, 52.9%) was seen as low-signal intensity on T2-weighted images, and was enhanced by Gd-DTPA (Figure 1A), followed by low-signal intensity on T2-weighted images that was not enhanced by Gd-DTPA (25 lesions, 29.4%) (Figure 1B), high-signal intensity on T2-weighted images enhanced by Gd-DTPA (10 lesions, 11.8%) (Figure 1C), and high-signal intensity on T2-weighted images not enhanced by Gd-DTPA (four lesions, 4.7%) (Figure 1D). In total, 56 lesions (65.9%) were seen on Gd-DTPA-enhanced, T1-weighted images, which was almost twice as many as were not enhanced. Most lesions (82.4%) were shown as low signal intensity on T2-weighted MR images.

The ratio of volume reduction of uterine leiomyomas measured and calculated on MR images, together with various imaging patterns after GnRH analogue treatment, are shown in Table II. The average volume reduction ratio of lesions, shown as low signal intensity on T2-weighted images and enhanced on Gd-DTPA, T1-weighted images, was 46.3 ± 27.7%. This ratio was significantly different compared with lesions shown as low signal intensity on T2-weighted images and not on Gd-DTPA-enhanced MR images (volume reduction ratio 14.0 ± 32.9%) (P < 0.001). There was also a statistically significant difference between lesions on Gd-DTPA-enhanced, T1-weighted images (volume reduction ratio 44.7 ± 27.8%) and those not enhanced (volume reduction ratio 17.8 ± 33.2%) (P < 0.001).

MR imaging patterns of the lesions reduced in volume by ≥50% are shown in Table III. The incidence of the lesions shown as low signal intensity on T2-weighted MR images and Gd-DTPA-enhanced, T1-weighted MR images was significantly higher (51%) than for those not enhanced (16%) (P < 0.01). Similarly, the incidence of lesions enhanced on Gd-DTPA enhanced, T1-weighted MR images (48.2%) was significantly higher than those not enhanced (20.7%) (P < 0.05).

Lesions unresponsive to GnRH analogue treatment (volume reduction ratio 0%, or lesion enlarged) are shown in Table IV. The incidence of the lesions shown as low signal intensity on T2-weighted MR images and not enhanced on Gd-DTPA, T1-weighted MR images (40%) was significantly higher than those that were enhanced (11%) (P < 0.001). Among the total GnRH-non-responsive lesions, the incidence of lesions enhanced on Gd-DTPA, T1-weighted MR images (34.5%) was significantly higher than those that were enhanced (12.5%; P < 0.001). Some lesions increased their volume after GnRH analogue treatment; four lesions were not enhanced by Gd-DTPA, but two did show enhancement.

The size and Gd-DTPA enhancement pattern of each uterine leiomyoma was also investigated. The mean pretreatment volume of uterine leiomyomas was 120.6 ± 200.0 ml in the enhanced group, but this was not significantly different from that of the negative-enhanced group (156.7 ± 242.4 ml). Neither was any correlation found between leiomyoma volume before treatment and the volume reduction ratio of leiomyoma after treatment. When the T2-weighted signal intensity patterns and Gd-DTPA enhancement patterns of leiomyomas were compared, high T2 signal intensity leiomyomas with negative enhancement (441.7 ± 283.2 ml) had a significantly larger volume than leiomyomas of low T2 signal intensity with enhancement (89.2 ± 124.1 ml) and low T2 signal intensity with negative enhancement (96.5 ± 189.2 ml) (Table V).

Among 85 leiomyoma found, 71 (84%) were intramurally located, 12 were subserosal and two were submucous. Mean lesion volumes were 60.7 ± 68.9 ml for subserosal, 147.2 ± 228.4 ml for intramural, and 4.9 ± 1.0 ml for submucous. In view of the very small number of submucous leiomyomas identified, these were excluded from the current study. Statistically, there was no significant difference between the lesion...
Figure 1. Four typical MR imaging findings of uterine leiomyoma before treatment. (A) Uterine leiomyoma shown as low-signal intensity on T2-weighted images and enhanced by Gd-DTPA. (B) Uterine leiomyoma shown as low signal intensity on T2-weighted images and not enhanced by Gd-DTPA. (C) Uterine leiomyoma shown as high-signal intensity on T2-weighted images and enhanced by Gd-DTPA. (D) Uterine leiomyoma shown as high signal intensity on T2-weighted images and not enhanced by Gd-DTPA. M = uterine leiomyoma; T2-WI = T2-weighted images; Gd-DTPA T1-WI = gadopentetate dimeglumine (Gd-DTPA)-enhanced T2-weighted images.

Table I. Magnetic resonance (MR) imaging of leiomyomatous nodules before treatment with GnRH analogue

<table>
<thead>
<tr>
<th>T2-weighted MR images</th>
<th>Low (n)</th>
<th>High (n)</th>
<th>Iso (n)</th>
<th>Total (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gd (+)</td>
<td>45 (52.9)</td>
<td>10 (11.8)</td>
<td>1 (1.2)</td>
<td>56 (65.9)</td>
</tr>
<tr>
<td>Gd (-)</td>
<td>25 (29.4)</td>
<td>4 (4.7)</td>
<td>0 (0)</td>
<td>29 (34.1)</td>
</tr>
<tr>
<td>Total</td>
<td>70 (82.4)</td>
<td>14 (16.5)</td>
<td>1 (1.2)</td>
<td>85 (100.0)</td>
</tr>
</tbody>
</table>

Values in parentheses are percentages.

Table II. The ratio of volume reduction (%) of uterine leiomyomas

<table>
<thead>
<tr>
<th>T2-weighted MR images</th>
<th>Low</th>
<th>High</th>
<th>Iso</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gd (+)</td>
<td>46.3 ± 27.7a</td>
<td>31.7 ± 27.5</td>
<td>90.6</td>
<td>44.7 ± 27.8b</td>
</tr>
<tr>
<td>Gd (-)</td>
<td>14.0 ± 32.8a</td>
<td>41.4 ± 29.1</td>
<td>–</td>
<td>17.8 ± 33.2b</td>
</tr>
</tbody>
</table>

Values are mean ± SD. Significant difference: a-a, P < 0.01; b-b, P < 0.05.

Table III. MR imaging patterns of the lesions reduced in volume by ≥50%

<table>
<thead>
<tr>
<th>T2-weighted MR images</th>
<th>Low</th>
<th>High</th>
<th>Iso</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gd (+)</td>
<td>23/45 (51)a</td>
<td>3/10 (30)</td>
<td>1/1 (100)</td>
<td>27/56 (48.2)b</td>
</tr>
<tr>
<td>Gd (-)</td>
<td>4/25 (16)b</td>
<td>2/4 (50)</td>
<td>–</td>
<td>6/29 (20.7)b</td>
</tr>
</tbody>
</table>

Values in parentheses are percentages. Significant difference: a-a, P < 0.01; b-b, P < 0.05.

Table IV. Lesions unresponsive to GnRH analogue treatment (volume reduction ratio was 0%, or the lesion was enlarged)

<table>
<thead>
<tr>
<th>T2-weighted MR images</th>
<th>Low</th>
<th>High</th>
<th>Iso</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gd (+)</td>
<td>5/45 (11)a</td>
<td>2/10 (20)</td>
<td>0/1 (0)</td>
<td>7/56 (12.5)b</td>
</tr>
<tr>
<td>Gd (-)</td>
<td>10/25 (40)a</td>
<td>0/4 (0)</td>
<td>–</td>
<td>10/29 (34.5)b</td>
</tr>
</tbody>
</table>

Values in parentheses are percentages. Significant difference: a-a, P < 0.01; b-b, P < 0.05.

Table V. Volume (ml) of uterine leiomyomas before treatment

<table>
<thead>
<tr>
<th>T2-weighted MR images</th>
<th>Low</th>
<th>High</th>
<th>Iso</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gd (+)</td>
<td>89.2 ± 124.1a</td>
<td>299.0 ± 371.7</td>
<td>5.6</td>
<td>120.6 ± 200.0</td>
</tr>
<tr>
<td>Gd (-)</td>
<td>96.5 ± 189.2b</td>
<td>441.7 ± 283.2ab</td>
<td>–</td>
<td>156.7 ± 242.4</td>
</tr>
</tbody>
</table>

Values are mean ± SD. Significant difference: a-a, P < 0.01; b-b, P < 0.05.

locations; neither was any statistically significant difference seen based on Gd-DTPA enhancement patterns. The volume reduction ratio of leiomyoma after treatment was 35.1 ± 29.6% for intramural lesions and 46.2 ± 41.4% for subserosal lesions (P = NS).

A comparison of signal intensities of T2-weighted MR images and Gd-DTPA enhancement patterns showed no significant difference of frequency for both subserosal and intramural leiomyomas. Neither was there any significant difference in terms of Gd-DTPA enhancement pattern.
Discussion

Uterine leiomyoma is the most frequently encountered tumour of the female genital tract, and is detected in 20–30% of adult women (Yen, 1999). It has been considered that the growth of uterine leiomyoma is influenced by ovarian steroids (Fuji, 1992), and investigations of the onset of ovarian steroid receptors have shown that sex steroid receptors appear in uterine leiomyoma more frequently than in the uterine myometrium. In addition, oestrogen receptors tend to be less suppressed in uterine leiomyoma owing to the action of progesterone (Fuji, 1992). Although the traditional view is that oestrogen is the major promoter of uterine leiomyoma growth, progesterone may be equally important for the development and growth of these lesions. Several studies (Rein et al., 1995; Ichimura et al., 1998; Nisolle et al., 1999) have strongly inferred that uterine leiomyoma may be under the influence of progesterone, and that this hormone may play a major role in their growth.

As a result of recent changes in the lifestyle of women in developed countries, for example late childbirth, conservative pharmacological treatment for uterine leiomyoma is increasingly preferred. As such a treatment, GnRH analogue was developed based on the close relationship between uterine leiomyoma proliferation and sex steroids, especially oestrogen. The mechanism of action of GnRH analogue treatment may be attributed to induction of the down-regulation of GnRH receptors in the pituitary gland, which leads in turn to endometrial atrophy and amenorrhoea. As ovarian leiomyoma tissues possess oestrogen receptors, it is not only the action of the oestrogen receptors but also the direct action of GnRH analogue (seen as GnRH binding sites in the leiomyoma tissues), the increase of uterine vascular resistance due to a low oestrogen state, and a reduction in the blood supply to the lesion that are thought to be related to the size reduction of uterine leiomyoma (Togashi, 1993; Sreenan et al., 1996).

On T2-weighted MR sagittal images, the uterine corpus shows three different zones during the reproductive period. The innermost zone is the endometrium, with high signal intensity, while the myometrium adjacent to the endometrium usually exhibits a distinct low signal intensity, and is known as the ‘junctional zone’. The myometrium of the outer two-thirds shows a medium signal intensity. It is unclear why the myometrium shows zonal differences on MR images (International Society for a Group Study on Pathophysiology of Obstetrics and Gynecology, 1999), but from a clinical standpoint, identification of the junctional zone is important in the differential diagnosis of adenomyosis from uterine leiomyoma, as well as the assessment of submucous myoma, which is surrounded by junctional zone.

With regard to MR imaging diagnosis of uterine leiomyoma, it has been reported that a typical uterine leiomyoma without degeneration is characterized by its clear margin and apparently lower signal intensity compared with that of the myometrium on T2-weighted MR image, which reflects a mixture of fibrous components and reduced blood flow (Okizuka et al., 1993). However, uterine leiomyomas are demonstrated as various MR imaging appearances. For example, low signal intensity with uneven high signal intensity spots on both T1- and T2-weighted images may be due to histological degeneration of leiomyoma, while low signal intensity on T1-weighted images and high signal intensity on T2-weighted images may be due to high vascularity in the leiomyoma. Furthermore, a relatively high signal intensity on T1-weighted images and a high signal intensity on T2-weighted MR images may be seen in cases of cellular leiomyoma, which has high parenchymal tissue density. A relatively high signal intensity on T1-weighted image, together with an extremely high signal intensity on T2-weighted image, may also be seen in cases of cellular atypia, which will make sarcomatous transformation (Togashi et al., 1988). In this way, MR imaging provides information on histological features and changes of uterine leiomyoma, and is therefore assumed to be an important tool in the prediction and evaluation of efficacies of conservative treatment for uterine leiomyoma.

Although few reports have detailed the correlation of GnRH treatment and MR imaging examination, it has been noted (Okizuka et al., 1993) that the differentiation between degenerated and intact uterine leiomyoma is possible on Gd-DTPA-enhanced MR images. Others (Oguchi et al., 1995) reported that since the ratio of uterine leiomyoma size reduction after GnRH therapy can be assessed on T2-weighted MR images, uterine leiomyoma could be classified into five types based on T2-weighted MR image findings. The size reduction ratio was found to be lowest (20.9%) in type 1 lesions (lower signal intensity than the myometrium), and highest (50.7%) in type 4 lesions (equivocal signal intensity to the myometrium). Histological study showed that many high signal intensity lesions had high vascularity, whereas low signal intensity lesions had low vascularity; hence a lesion seen as low signal intensity on both T1- and T2-weighted images is considered to be less responsive to conservative GnRH analogue treatment, while a lesion with uniform high signal intensity is considered to be responsive to such treatment (Togashi, 1993; Oguchi et al., 1995; Demopoulos et al., 1997).

In the current study, T2-weighted MR image findings were classified into three patterns, while Gd-DTPA enhanced T1-weighted MR images findings were also added in order to analyse simply and clearly the characteristic features of uterine leiomyoma. Consequently, ~50% of uterine leiomyomas were shown as low signal intensity on T2-weighed MR images, were enhanced on Gd-DTPA-enhanced T1-weighted MR images, and had a volume reduction ratio of 46.3% after treatment. In contrast, the volume reduction ratio was significantly lower (17.8%) in uterine leiomyomas that were not enhanced by Gd-DTPA in T1-weighted MR images. Accordingly, when the lesion was not enhanced by Gd-DTPA in T1-weighted MR images, the efficacy of GnRH analogue treatment was expected to be low, irrespective of the T2-weighted MR images finding. On the other hand, if the lesion was enhanced by Gd-DTPA in T1-weighted MR images, ~50% of the leiomyomas were expected to be responsive to GnRH analogue treatment.

Although the results of the current study showed that lower signal intensity lesions with Gd-DTPA-enhanced T1-weighted MR images were more responsive to GnRH treatment, these
findings were at variance with results from others. This variation might be attributable to the relatively few number of patients who had a lesion shown as iso-signal intensity to that of the myometrium. Moreover, histological confirmation was not available in all subjects because surgical management was not applied in all cases. It has been suggested that certain components of uterine leiomyomas show low signal intensity on T2-weighted MR images, including tight smooth muscle tissues (with less degeneration) and hyaline degeneration. The latter is not enhanced by Gd-DTPA because of its amorphous structure; therefore, if a uterine leiomyoma is enhanced to some extent, it may be less degenerated and be responsive to pharmacological treatment, even though it appears as low signal intensity on T2-weighted MR images. However, when a uterine leiomyoma with low signal intensity on T2-weighted MR images is not enhanced, it shares mainly hyaline degeneration, suggesting less responsiveness to the treatment. The results of the current investigation agreed well with this assumption.

By contrast, the components of uterine leiomyoma which show high signal intensity on T2-weighted MR images include cellular uterine leiomyoma, oedema, cystic degeneration and myxoid degeneration. Cellular uterine leiomyoma tends to be well-enhanced by Gd-DTPA, and appears as a very high signal intensity on T2-weighted MR images (Yamashita et al., 1993). However, cellular uterine leiomyoma is a rather rare disease, and its responsiveness to treatment has, in the past, not been identified due to insufficient comparative patient numbers. In addition to cellular uterine leiomyoma, it is known that oedema is well enhanced (Mittl et al., 1991), but cystic degeneration is not enhanced by Gd-DTPA. It has also been reported that myxoid degeneration is not enhanced during the ordinary examination time (Ueda et al., 1999). Therefore, if a lesion shows high signal intensity on T2-weighted MR images and is enhanced, it would be an oedema—which is presumed to be responsive to the treatment. If the lesion is not enhanced however, it is presumed to be cystic degeneration or myxoid degeneration, suggesting less responsiveness. In general, hyaline degeneration is the most frequently encountered pathology in this type of disease, and has been found occasionally confused with oedema. Hence, misdiagnosis may occur when any treatment effect is evaluated by the signal intensity of T2-weighted images alone.

Recently, it was reported that, when using Gd-DTPA enhanced scanning, no relationship was found regarding the response to agonist treatment which differed from the current results (Broekmans et al., 1996), and the following reasons might explain these findings. First, although these authors (Broekmans et al., 1996) used a 0.6 T magnetic scanning unit, only a 1.5 T magnetic scanning unit was used in the current study. On the basis of the great difference in magnetic field strength, there should be differences in signal-to-noise ratio (S/N) and contrast-to-noise ratio (C/N). Another point is that since the number of excitation used by others was 4, it may have taken more time to obtain images after contrast enhancement compared with our scanning method. Furthermore, the other group studied the correlation between size reduction of the lesion after treatment and quantitative evaluation of signal intensities in uterine leiomyoma and adjacent s.c. adipose tissue and their calculated ratio. By contrast, we qualitatively evaluated and compared contrast-enhanced signal intensities of uterine leiomyoma and the uterine myometrium.

Thus, T2-weighted MRI findings alone are considered to be insufficient, because uterine leiomyoma may exhibit various features. Therefore, findings of Gd-DTPA enhanced T1-weighted images were added to evaluate the efficacy of GnRH analogue, since this will reflect factors of vascular flow state. In conclusion, it should be emphasized that in order to evaluate the treatment effect of GnRH analogue therapy in uterine leiomyoma, a combination of signal intensity patterns of T2-weighted images and Gd-DTPA-enhanced T1-weighted images is more useful than evaluation based on signal intensity of T2-weighted images alone.

Although it would be better, and clearer, to investigate the treatment effect of uterine leiomyoma based on one leiomyoma in one patient, the lesions were selected randomly, with a maximum of three in one patient, as the main purpose of the current study was to predict GnRH treatment efficacy for ‘each’ leiomyoma in order to differentiate responders from non-responders before treatment was commenced. This may have led to a lack of control over the influence of certain types of response to treatment, as the response of several leiomyomas in a single patient may be interrelated.

The postulation has been made (Brosens et al., 1998) that cytogenetic rearrangements in uterine leiomyomas are associated with a loss of steroid hormone dependency. This may alter the growth potential of the tumour, since in GnRH analogue-treated and menopausal women, 48% of myomas >4 cm were associated with clonal abnormalities, while submucous myomas had significantly fewer clonal abnormalities (12%) than either subserosal (29%) or intramural myomas (35%). Furthermore, it has been observed clinically that GnRH analogue treatment is effective in 95% of women with submucous myomas (Donnez et al., 1998). However, in the current study no differentiation could be found for the response of GnRH analogue treatment in terms of both size and location of uterine leiomyoma, as there might be variations among cases. In particular, submucous leiomyomas could not be investigated as only two such lesions were found.

In conclusion, it is suggested that the prediction of any GnRH treatment effect is possible by analysing signal intensity patterns and Gd-DTPA enhancement patterns of MR imaging before treatment of uterine leiomyoma.

References
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