

## 1 Case Study

2 Evaluation of the dose received by ovaries in the treatment  
3 of a desmoid tumour presenting in the lower extremity using  
4 intensity-modulated radiotherapy tomotherapy

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## 9 Abstract

10 *Background:* Desmoid tumour is a rare neoplasm occurring intra- and extra-abdominally.

11 *Method:* In this study, a lower extremity desmoid tumour located close to the ovaries was irradiated  
12 with tomotherapy after surgery in a 16-year-old female patient. 30 fractions defined for delivery of 54 Gy  
13 were administered to the patient.

14 *Result:* The planning target volume and organs at risk doses were evaluated and the ovary doses were  
15 discussed for fertility.

16 *Conclusion:* The patient tolerated the radiotherapy well. During radiotherapy, only grade 1 skin toxicity occurred.

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17 *Keywords:* desmoid tumour; IMRT; ovary; tomotherapy

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## 19 INTRODUCTION

20 Desmoid tumour (DT) is a neoplasm also  
21 previously named 'aggressive fibromatosis', that  
22 originates from superficial or deep musculo-  
23 aponeurotic structures. DT can occur intra-  
24 or extra-abdominally. It is a rare tumour, the  
25 incidence is 2–4 per million. It occurs twice more  
26 often in women than in men and is more likely

to arise in the third and the fourth decade of life,  
however it can occur in children.

DTs are slow-growing mesenchymal tumours  
with a high predilection for local recurrence.  
Surgery, radiotherapy (RT), chemotherapy,  
hormonal therapy, anti-inflammatory therapy,  
vitamin C or a combination of all these  
modalities are used to treat DT.<sup>1</sup> Adjuvant RT is  
a treatment aimed at increasing local control,  
especially for patients with high-grade tumour  
and positive microscopic surgical margin. RT  
significantly decreases local relapse when  
compared with patients who receive only

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surgical interventions. According to Nuyttens compilation of 22 articles, the local control rate is 78% among patients who receive both surgical operation and RT, however the local control rate is 68% among patients who receive surgery only.<sup>2</sup>

## CASE

A 16-year-old female had repeated operations for DT located under the right toe, 4 years ago. Subsequently, the distal aspect of the left foot was amputated and the patient administered two cycles of chemotherapy. The chemotherapy was stopped at the patient's own request. On follow up, the patient received further surgery to remove a bulky tumour located in the right femur. Pathology demonstrated this was a DT, and the surgical borders were tumour positive. It was decided to treat the patient with RT.

## MATERIALS AND METHOD

Before starting the adjuvant intensity-modulated radiotherapy (IMRT) planning, the patient was immobilised in the supine position using a vacuum board with legs apart. For treatment planning a computed tomography scan was obtained using 3 mm. The target volume and organs at risk (OaRs) were defined by the physician. To cover all tumour extension, the planning target volume (PTV) was extended from the right inguinal fossa to the distal end of the femur. The femur, femoral head, ovaries, bladder, rectum, uterus were all delineated as OaRs by using the velocity planning software.

The treatment was planned to deliver 54 Gy in 30 fractions. The PTV received 95% of the 54 Gy. Tomotherapy-based IMRT plan was optimised on the TomoHi-art work station. Optimisation parameters were as follows; field width was 5 cm, pitch was 0.25, planning modulation factor was 2.00, plan calculation grid was normal (0.610 × 0.610 cm).

OaRs doses were evaluated using RTOG (Radiation Therapy Oncology Group) protocols<sup>3</sup> and quality of PTV was evaluated with parameters

of homogeneity index (HI) and the conformity index (CI).

CI was calculated using the following formula for PTV:

$$CI = (TV_{PIV})^2 / (TV \times PIV)$$

$TV_{PIV}$  is the target volume covered by the prescription isodose volume, TV is target volume and PIV is the prescription isodose volume in the Formula.<sup>4</sup>

The HI formula was as follows:

$$HI = (D_5 - D_{95}) / D_p$$

$D_5$  and  $D_{95}$  represent the doses received by the 5 and 95% volumes of PTV, respectively, and  $D_p$  is the prescribed dose.<sup>5</sup>

## RESULTS

Coronal, sagittal and transverse isodose distributions of the planning and dose volume histograms (DVH) including PTV and critical organs are showed in Figures 1a and 1b. PTV and critical organs maximum, minimum and median doses are demonstrated in Table 1. Because the patient is so young, it is important that the PTV dose and the dose to the ovary is kept to a minimum so as not to impair fertility.

Maximum, minimum and median doses of PTV were 57.02 Gy, 35.69 Gy and 55.56 Gy, respectively (Table 1). In all, 5% of the femoral head received ~55 Gy, 10% of the femoral head receives 53 Gy and the femur receives an average of 36.24 Gy. The uterus receives a maximum of 15.49 Gy and an average of 7.91 Gy. The right ovary receives a maximum of 36.8 Gy, and an average of 16.13 Gy. The left ovary receives a maximum of 12.47 Gy and an average of 6.49 Gy. The HI, the CI and the treatment time were 0.8, 1.056 and 413.4 MU, respectively.

## DISCUSSION

Reducing the dose to the critical organs especially the ovary dose was problematic given the extent of the area requiring RT. Ionising radiation has adverse effects on the ovary at all ages.

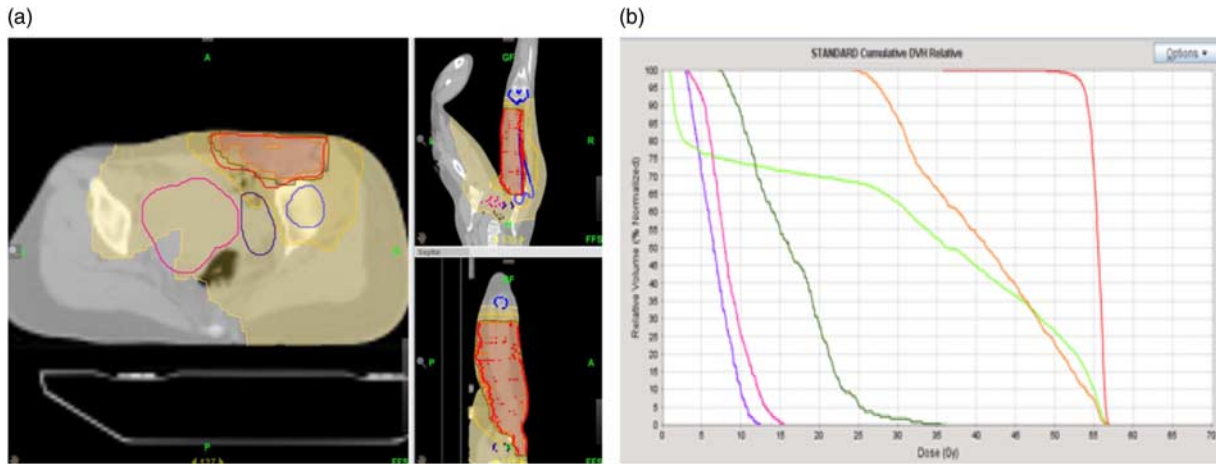


Figure 1. (a) Isodose distribution for coronal, sagittal and transverse planes (Dark Orange colour: 54 Gy, light orange colour: 51.3 Gy, dark yellow: 27 cGy, light yellow: 5.4 cGy—red: planning target volume (PTV), pink: uterus, light blue: right femoral head, dark blue: right femur, purple: right ovary) (b) Dose volume histogram (DVH) distribution (red: PTV, orange: right femoral head, light green: right femur, dark green: right ovary, pink: uterus, purple: left ovary).

**Table 1.** Doses of planning target volume (PTV) and Organ's at Risk (OaR's) (right and left ovaries, right femur, right femoral head and uterus)

	Maximum dose (Gy)	Minimum dose (Gy)	Median dose (Gy)
PTV	57.02	35.69	55.56
Right ovary	36.18	7.04	16.13
Left ovary	12.47	2.99	6.49
Right femur	56.73	0.93	36.24
Right femoral head	56.55	24.21	41.31
Uterus	15.49	3.21	7.91

was decreased to 6.49 Gy. Meirou describes the dose of radiation required to destroy 50% of primordial follicles (LD50) has previously been judged to be <4 Gy—an estimate later deemed to be an over-simplification.<sup>6</sup> Although doses of >6 Gy consistently cause permanent primary hypogonadism in women over age 40 years, the impact of lower doses varies, with reports of conceptions in women under 20 years of age who have received up to 30 Gy.<sup>9</sup>

121 The degree and persistence of the damage to the  
 122 ovary is dependent on the dose, irradiation  
 123 field and the patient's age when irradiated.  
 124 It is necessary to shield the ovaries using beam  
 125 shaping blocks or by placing the treatment fields to  
 126 avoid direct irradiation to the ovaries, but in some  
 127 treatments treating the ovaries cannot be  
 128 avoided.<sup>6-8</sup>

129 Modern RT techniques such as image-guided  
 130 radiotherapy (IGRT) and IMRT are more  
 131 effective than classical RT techniques and allow  
 132 for the reduction of the dose to OaRs. In this  
 133 study, the doses of the femur, femoral head  
 134 and uterus as defined as OaR's were acceptable.  
 135 Right ovary was very close to PTV therefore  
 136 decreasing the dose to the ovary was not an  
 137 option. The average dose to the right ovary  
 138 was decreased to 16.13 Gy. Dose to the left ovary

149 Using the best available model for follicle  
 150 decline, Wallace *et al.*<sup>10</sup> reported their calculation  
 151 of the radio-sensitivity of the human oocyte in  
 152 terms of LD50. According to Wallace *et al.*,  
 153 for the a 16-year-old patient, the effective  
 154 (ovarian failure in 97.5%) sterilising dose is  
 155 about 18 Gy (upper) and the mean (ovarian  
 156 failure in 50%) sterilising dose is about 16.5 Gy  
 157 (lower) of radiation for a given treatment  
 158 age. According to this study, the dose to the  
 159 left ovary in this patient is within limits, however  
 160 the maximum value to the right ovary is out  
 161 of limits. Dose to the left ovary within limits,  
 162 however, this does not necessarily indicate  
 163 that ovarian failure will not occur. According  
 164 to Wallace, for our patient and the dose to  
 165 the left ovary being ~6.49 Gy, the predicted  
 166 age of ovarian failure, with 95% confidence  
 167 limits of 25.4 (low), 29.3 (mean) and 33.2  
 168 (high).<sup>11</sup>

169 The patient is followed up with estradiol,  
170 follicular stimulating hormone and leutenising  
171 hormone tests periodically. In the last follow-up  
172 menstrual irregularity was noted in the patient.

## 173 CONCLUSION

174 The use of RT is likely to improve local control  
175 in DT. However, RT is more likely to result  
176 in long-term complications and an impact on  
177 fertility, therefore individual decision making  
178 and special attention to OaR is warranted. The  
179 patient tolerated the RT well and only grade 1  
180 skin toxicity occurred.

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## 183 Conflicts of Interest

184 None.

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