UK National cohort of anal cancer treated with intensity modulated radiotherapy: One-year oncological and patient reported outcomes

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Abstract

Background

Concurrent chemoradiotherapy is standard treatment for anal cancer. Following national UK implementation of intensity-modulated radiotherapy (IMRT) this prospective, national cohort evaluates the 1-year oncological outcomes and patient-reported toxicity outcomes (PRO) after treatment.

Materials and Methods

A national cohort of UK cancer centres implementing IMRT was carried out between February to July 2015. Cancer centres provided data on oncological outcomes including survival, and disease and colostomy status at 1-year. EORTC-QLQ core (C30) and colorectal (CR29) questionnaires were completed at baseline and 1-year follow-up. The PRO scores at baseline and 1-year were compared.

Results

40 UK Cancer Centres returned data with a total of 187 patients included in the analysis. 92% received mitomycin with 5-flurouracil or capecitabine. 1-year overall survival was 94%; 84% were disease-free and 86% colostomy-free at 1-year follow up. At 1-year, PRO results found significant improvements in buttock pain, blood and mucous in stools, pain, constipation, appetite loss, and health anxiety compared to baseline. No significant deteriorations were reported in diarrhoea, bowel frequency, and flatulence. Urinary symptom scores were low at 1-year. Moderate impotence symptoms at baseline remained at 1-year and a moderate deterioration in dyspareunia reported.

Conclusions

With national anal cancer IMRT implementation, at this early pre-defined time point, 1-year oncological outcomes were reassuring and result in good disease-related symptom control. 1-year symptomatic complications following CRT for anal cancer using IMRT techniques appear to be relatively mild. These PRO results provide a basis to benchmark future studies. ~~Future studies should use an anal cancer specific PRO (e.g. EORTC QLQ ANL27) to accurately assess patient experience.~~

Introduction

Concurrent chemoradiotherapy is the standard of care for anal cancer treatment[1, 2]. In 2012, the UK department of health recommended implementation of intensity modulated radiotherapy (IMRT) (including volumetric modulated arc therapy (VMAT) and tomotherapy) with the aim of reducing toxicity from radiotherapy through sculpting of the beams and dose[3]. Within clinical trials, radiotherapy protocol deviations are known to impact on treatment failure and oncological outcomes[4]. Therefore, to optimise implementation of IMRT in a rare cancer, the Royal College of Radiologists supported the development of a national protocol and implementation strategy[5]. This national cohort was carried out with the aim of collecting prospective data to investigate IMRT delivery[6], to assess early toxicity[7], oncological outcomes and health-related quality of life (HRQOL).

A small number of studies in anal cancer, including prospective phase II trials, have reported on improved disease outcomes and treatment-related acute toxicity with the introduction of IMRT techniques[8-11]. Cross-sectional studies using patient-reported outcomes (PROs)

have found patients report long-term toxicity related to bowel, urinary and sexual dysfunction post-treatment[12, 13]. However, there is a lack of prospectively collected PROs measuring toxicity and HRQOL following anal cancer chemoradiotherapy from both IMRT and conformal techniques[13]. Baseline PRO data is important to be able to establish the true symptomatic benefit of treatment and to distinguish between toxicity and pre-morbid symptoms. In addition, there is also a lack of data outside of single-centre series. This paper presents the prospective evaluation of the impact of IMRT on patient-reported toxicity including HRQOL at 1-year in a national anal cancer cohort supplemented with oncological outcomes.

Materials and Methods

Prospective data collection from all UK National Health Service (NHS) cancer centres (n=56) in patients with a diagnosis of anal cancer starting IMRT over a 6-month period from 9 February to 27 July 2015 was requested. Full details are reported elsewhere[6]. Data collection was performed by the RCR as part of a national prospective cohort program in which approval was obtained by each NHS institution's research and governance board with a pre-planned 1-year follow-up schedule.

Patient demographic data at baseline included age, gender, stoma status, HIV and smoking status. Tumour and treatment information included TNM staging, radiotherapy dose and fractionation and concurrent chemotherapy schedule. Acute toxicity data was collected weekly during treatment using CTCAEv4[14] and reported grade 3/4 toxicity in any category

used in the analysis. Full details of demographics and acute toxicity have been reported previously[6].

Patients were invited to complete the validated European Organisation for Research and Treatment of Cancer QOL questionnaires (EORTC-QLQ) core module (C30) and colorectal cancer module (CR29)[15, 16]. An anal cancer-specific module was not available at the time of recruitment[17]. The C30 is a generic questionnaire including items on overall HRQOL, physical, role, social, emotional and cognitive function as well as generic symptoms affecting cancer patients including fatigue, diarrhoea and pain. CR29 addresses disease-specific concerns including bowel, urinary and sexual symptoms.

PRO collection was coordinated by clinical teams at each cancer centre and patients were invited to complete paper questionnaires at two timepoints – baseline (prior to or on day 1 of starting radiotherapy) and at 1-year. Invitations to report 1-year follow up data were sent between 14 July 2016 and 18 November 2016 via three email reminders to clinical teams (Range 353-648days). Paper questionnaires were either handed out at clinic appointments for completion or sent to patients in the post with a return (stamped) envelope at the discretion of the clinical team. Resources for this national program were restricted.

Descriptive and regression analyses were performed using Stata v13.1[18]. Descriptive statistics were used to describe patient, clinical and tumour characteristics. Descriptive analysis was performed on 1-year oncological outcomes as event rates were too low to carry out more extensive analyses. Disease-free status was defined as disease that had

achieved a complete response and not demonstrated recurrence[19] and missing data explored using logistic regression.

Exploratory analyses of EORTC QLQs and handling of missing data were performed according to EORTC guidelines, using a process of imputing missing values in scaled responses[20]. All item responses from the PROs were converted from a four-point Likert-type scale through a linear transformation onto a 0-100 scale. Higher scores for symptom items reflect more severe symptoms (i.e. 'not at all'=0; 'a little'=33.3; 'quite a bit'=66.6; 'very much'=100); higher scores for function items reflect a better level of functioning[20]. A minimum important difference (MID) was classified as a small change in scores from 5 to 10 points, moderate differences as a change up to 20 points and large differences as a change in scores of >20[21].

Mean and paired differences between baseline PRO scores and 1-year follow-up were evaluated. A two-sided t-test was used to evaluate statistical significance with a p-value <0.01 deemed to be significant, after Bonferroni correction for multiple comparisons. Multivariable linear regression analysis was performed to evaluate the impact of age, gender, acute (any) grade 3/4 toxicity, tumour stage and nodal stage on PRO items ($p<0.01$). Reasons for missing PRO data at baseline and 1-year follow up were explored using multivariable logistic regression, including age, gender, disease status, cancer centre, T stage and baseline PRO completion rates as confounders. An exploratory analysis compared mean PRO scores (for pre-defined PRO items taken from CORMAC core outcome set) at baseline and 1-year by risk groups; early stage T1/2N0 versus locally advanced T3/4 and/or N+[19, 22].

Results

Patient characteristics

1-year follow up data was collected in 40 UK Cancer Centres (71%), with numbers of participants included from each centre ranging from 1-13 participants (Median 4 per centre). Patient and tumour characteristics are summarised in Table 1 and 2 respectively. All 187 patients who received radical (curative intent) IMRT were included in this analysis, including patients who received full dose IMRT adherent to UK guidance (n=157)[6], those who received full dose IMRT not strictly adherent to UK guidance (n=23) and those receiving reduced dose IMRT (n=7) (see supplementary figure). Median radiotherapy dose received was 53.2Gy in 28 fractions(F) (Range 30-53.2Gy in 10-30F); T1/2 received median dose 50.4Gy in 28F (Range 30-54Gy in 10-30F) and T3/4 received median dose 53.2Gy in 28F (Range 40-54Gy in 15-30F). The majority of patients (n=153) completed full dose chemotherapy (n=27 dose reduced/omitted secondary to toxicity; n=7 no chemotherapy given) (see [6] for more details).

1-year survival data was available for 109 (58.2%) patients during follow-up. At 3-months no patients were known to have died. At 6-months 2 deaths were known to have occurred - both patients had residual local disease at 3-months. At 1-year, 6 patients in total had died - 94% 1-year overall survival. All 6 patients had evidence of local or distant disease, with 4 patients with residual local disease reported at 3-months. Disease-free survival status was available on 107 patients (57.2%) (2 patients were alive with unknown disease status). At 1-year, 84 were disease-free (78.5%), and 13 had local disease failure reported (5 underwent salvage surgery; 5 local regional failure; 3 LRR and metastatic disease) (12.1%). Table 3

presents 1-year oncological outcomes by patient, treatment and disease characteristics. The event rate (6 deaths) was too low to comment on any trends in the data. ~~Of the 6 deaths, proportionally more were men, aged ≤62 years, T3/4 tumours, current smokers and node positive at presentation.~~ 86% of patients were colostomy-free at 1-year (n=97/113). In regards missing data, centres either returned oncological outcome data or did not return any.

Exploratory PRO and HRQOL analysis

A total of 121 (65%) of patients reported some PRO data at either time-point, with 115 (61%) completing at least one PRO item at baseline and 57 (30%) at 1-year. 103 (55%) had complete data across all subscales at baseline and 54 (29%) at 1-year follow up. 43 (23%) of patients have complete subscale data at both time-points. No patient, clinical or tumour characteristics predicted missing PRO data. At baseline, only cancer centre appeared to predict missing questionnaires reflecting the administration approach to PRO data collection (p=0.02). At 1-year, there were no significant predictors of missing questionnaire data.

Table 4 describes the PRO mean scores at baseline and 1-year follow-up and mean and paired differences. Pain, constipation, appetite loss, anxiety, blood and mucous in stools, and buttock pain were all significantly improved at 1-year (mean differences). On review of MID between scores at baseline and 1-year, only dyspareunia showed a moderate clinical deterioration in mean scores (14.5 to 29.5). Otherwise moderate improvements were noted for role and emotional functioning and symptom scores: pain, constipation, appetite loss, anxiety, blood and mucous in stools. A large improvement in buttock pain from baseline was reported.

In terms of 1-year toxicity, it is reassuring that there was no clinically significant deteriorations reported with PRO items on diarrhoea, bowel frequency, flatulence, urinary frequency or impotence. Mean scores at 1-year for all bowel items ranged between 19.1 to 38.8 correlating to a patient reporting a 'mild' symptom[23]. Stoma scores are not included due to low numbers of patients reporting (n=13 at baseline and n=6 at 1-year).

The sample size for sexual toxicity items was small as only 34% of women reported on symptoms (n=46) and 50% of men (n=26). However, impotence scores for men remained relatively poor (mean score 46.6 – moderate symptoms) at 1-year but did not significantly deteriorate after treatment. For women, dyspareunia showed a moderate deterioration in mean scores but overall the 1-year mean score (29.4) relates to 'mild' symptoms.

The items with the most severe symptom mean scores at 1-year were flatulence, impotence, libido (for both men and women), and health anxiety. Although, both health anxiety and female libido showed a moderate and small improvement, respectively, from baseline scores. All other changes were minor. In regards HRQOL and function, moderate improvements at 1-year were noted for role and emotional functioning.

Regression analysis on predictors of significant PRO change between baseline and 1-year found change in pain scores was predicted by gender, with women reporting less of an improvement in pain scores over time (p=0.004); and acute G3/4 toxicity, with patients reporting a greater improvement in pain scores if they had reported any G3/4 toxicity during treatment or if this data was unknown as compared to patients with no G3/4 toxicity

(p=0.007). Similarly, change in buttock pain scores found women reporting less improvement in pain over time (p=0.01).

The exploratory analysis by risk groups (supplementary file), found locally advanced tumours have poorer baseline scores but report relatively greater improvements in function and cancer symptoms. In comparison, patients with early stage tumours are less compromised by cancer-related issues at baseline but have a proportionally greater change in scores by 1-year representing more toxicity-related issues.

Discussion

To our knowledge this is the largest, multicentre prospective cohort of 1-year oncological outcomes including PRO assessment of anal cancer patients treated with curative intent IMRT. The results provide a comprehensive evaluation of patients treated in routine practice in the UK.

The 1-year oncological outcomes found patients to have reassuringly high overall (94%), disease-free (84%) and colostomy-free (86%) survival in line other prospective studies of IMRT and randomised studies of conformal radiotherapy in anal cancer[2, 9, 24]. ~~There was a trend towards poorer outcomes being seen in male patients, current smokers, T3/4 and positive lymph nodes, as seen in other studies (including ACTII)[25]. Although due to the low event rate, these observed differences may be entirely due to chance alone.~~

The toxicity rates for all symptoms are generally low and improvements in disease-related symptoms, such as buttock pain and per rectal bleeding, significant. Importantly at 1-year, there were no significant deteriorations seen in bowel toxicity items including diarrhoea, bowel frequency, and flatulence, although flatulence symptom scores remained moderately severe (40.2). Urinary symptoms also did not significantly deteriorate at 1-year, although studies of pelvic radiotherapy with longer follow up have found that whilst bowel symptoms may improve after 1-year, urinary symptoms may deteriorate over a longer timeframe[26]. Whilst the sample for patients reporting on sexual function is small, it is important to note that dyspareunia deteriorated moderately at 1-year; and impotence symptom scores remained moderately severe, with a relatively greater deterioration seen in earlier cancers.

The 1-year PRO toxicity scores are similar to those reported in single-centre series of patients treated with IMRT[9, 27]. Although the use of different questionnaires and quality of reporting can make it challenging to directly compare results with other studies, the rates of late toxicity for bowel and erectile function using IMRT appear to be lower than cross-sectional series of patients treated with conformal techniques[28-31]. These findings are likely to reflect the sculpted dose around bowel and penile bulb structures resulting in reduced dose anteriorly[32]. For example, within the current study at 1-year patients reported mild diarrhoea symptoms (mean 16.4; SD22.0). Similarly, contemporary studies of patients treated with IMRT report mild symptoms with mean scores ranging from 12-22.8[9, 27]. In comparison, older studies have reported moderate diarrhoea symptom scores with mean scores between 27-34.6[28, 30, 31, 33]. Similarly, large to moderate improvements using IMRT are observed with symptoms of flatulence, faecal incontinence and impotence[27, 30, 31]. Our rates of dyspareunia, urinary frequency and incontinence were

similar to results from previous conformal and IMRT studies. Vaginal doses remain high as the structure is directly adjacent to the high dose tumour volume, whilst bladder symptoms may be more reflective of pre-morbid symptoms as minimal change was observed from baseline[34, 35].

The exploratory analysis lends credence to the need to improve symptoms with a significant impact on QOL, such as flatulence, dyspareunia and impotence, and this should be a target for future studies de-escalating dose in patients with low-risk anal cancer[22]. Indeed, these data provide a benchmark to test improvements in PRO from reduced dose IMRT in early stage disease and to assess any potential 'cost' in PRO from efforts to improve locoregional control in advanced disease with increasing radiotherapy doses, as is being tested in the ongoing platform trial, PLATO (personalizing anal cancer radiotherapy dose; registry no. ISRCTN88455282)[22].

Due to the restricted resources available for national programs, there are missing data for both PRO and oncological outcomes, more so at 1-year follow-up. The event rate therefore could be underestimated although PRO scores and oncological event rates were similar to ~~that~~ expected. This demonstrates the limitations of unfunded multi-centre national audit programs. However, it is reassuring than no patient, clinical or tumour characteristics appeared to predict missing data. Only centres failing to return data appears to be in effect, which provides a strong argument in support of the reliability of these results. The authors also acknowledge that 1-year is an early timepoint in follow-up. A further limitation is standardised quality assurance for IMRT implementation and delivery. At the time of patient recruitment, no validated anal cancer specific PRO existed and therefore as in other studies,

the EORTC-QLQ CR29 was used for evaluation. Whilst this provides good quality data, a number of important long-term toxicity issues are missing; of particular note, symptoms related to bowel urgency, toilet dependency, and vaginal symptoms such as vaginal dryness and stenosis. These issues are present in the newly developed EORTC-QLQ ANL27, which is currently under phase IV international validation testing and included in the PLATO trial[17, 36]. Future studies should use the EORTC-QLQ ANL27 to provide an accurate understanding of patient disease and toxicity burden [37] and prioritise a priori selection of key PRO items highlighted in CORMAC, the anal cancer core outcome set, for hypothesis testing[19].

Conclusions

In comparison to other studies reporting PRO and HRQOL in anal cancer, our study provides PRO data in a multicentre prospective setting. The effective implementation of IMRT in a national setting was reported previously[6]. At 1-year, early oncological outcomes were reassuring and result in good disease-related symptom control measured with PROs. In comparison to historical series of conformal radiotherapy, these results also suggest benefits in the reduction of bowel and male sexual dysfunction at 1-year. These findings, as well as providing prospective PRO toxicity data to better understand patient experience, may also provide the basis for benchmarking future studies.

Conflict of Interest statement

None declared

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Results

40 UK Cancer Centres returned data with a total of 187 patients included in the analysis. 92% received mitomycin with 5-flurouracil or capecitabine. 1-year overall survival was 94%; 84% were disease-free and 86% colostomy-free at 1-year follow up. At 1-year, PRO results found significant improvements in buttock pain, blood and mucous in stools, pain, constipation, appetite loss, and health anxiety compared to baseline. No significant deteriorations were reported in diarrhoea, bowel frequency, and flatulence. Urinary symptom scores were low at 1-year. Moderate impotence symptoms at baseline remained at 1-year and a moderate deterioration in dyspareunia reported.

Conclusions

With national anal cancer IMRT implementation, at this early pre-defined time point, 1-year oncological outcomes were reassuring and result in good disease-related symptom control. 1-year symptomatic complications following CRT for anal cancer using IMRT techniques appear to be relatively mild. These PRO results provide a basis to benchmark future studies.

Introduction

Concurrent chemoradiotherapy is the standard of care for anal cancer treatment[1, 2]. In 2012, the UK department of health recommended implementation of intensity modulated radiotherapy (IMRT) (including volumetric modulated arc therapy (VMAT) and tomotherapy) with the aim of reducing toxicity from radiotherapy through sculpting of the beams and dose[3]. Within clinical trials, radiotherapy protocol deviations are known to impact on treatment failure and oncological outcomes[4]. Therefore, to optimise implementation of IMRT in a rare cancer, the Royal College of Radiologists supported the development of a national protocol and implementation strategy[5]. This national cohort was carried out with the aim of collecting prospective data to investigate IMRT delivery[6], to assess early toxicity[7], oncological outcomes and health-related quality of life (HRQOL).

A small number of studies in anal cancer, including prospective phase II trials, have reported on improved disease outcomes and treatment-related acute toxicity with the introduction of IMRT techniques[8-11]. Cross-sectional studies using patient-reported outcomes (PROs) have found patients report long-term toxicity related to bowel, urinary and sexual dysfunction post-treatment[12, 13]. However, there is a lack of prospectively collected PROs

measuring toxicity and HRQOL following anal cancer chemoradiotherapy from both IMRT and conformal techniques[13]. Baseline PRO data is important to be able to establish the true symptomatic benefit of treatment and to distinguish between toxicity and pre-morbid symptoms. In addition, there is also a lack of data outside of single-centre series. This paper presents the prospective evaluation of the impact of IMRT on patient-reported toxicity including HRQOL at 1-year in a national anal cancer cohort supplemented with oncological outcomes.

Materials and Methods

Prospective data collection from all UK National Health Service (NHS) cancer centres (n=56) in patients with a diagnosis of anal cancer starting IMRT over a 6-month period from 9 February to 27 July 2015 was requested. Full details are reported elsewhere[6]. Data collection was performed by the RCR as part of a national prospective cohort program in which approval was obtained by each NHS institution's research and governance board with a pre-planned 1-year follow-up schedule.

Patient demographic data at baseline included age, gender, stoma status, HIV and smoking status. Tumour and treatment information included TNM staging, radiotherapy dose and fractionation and concurrent chemotherapy schedule. Acute toxicity data was collected weekly during treatment using CTCAEv4[14] and reported grade 3/4 toxicity in any category used in the analysis. Full details of demographics and acute toxicity have been reported previously[6].

Patients were invited to complete the validated European Organisation for Research and Treatment of Cancer QOL questionnaires (EORTC-QLQ) core module (C30) and colorectal cancer module (CR29)[15, 16]. An anal cancer-specific module was not available at the time of recruitment[17]. The C30 is a generic questionnaire including items on overall HRQOL, physical, role, social, emotional and cognitive function as well as generic symptoms affecting cancer patients including fatigue, diarrhoea and pain. CR29 addresses disease-specific concerns including bowel, urinary and sexual symptoms.

PRO collection was coordinated by clinical teams at each cancer centre and patients were invited to complete paper questionnaires at two timepoints – baseline (prior to or on day 1 of starting radiotherapy) and at 1-year. Invitations to report 1-year follow up data were sent between 14 July 2016 and 18 November 2016 via three email reminders to clinical teams (Range 353-648days). Paper questionnaires were either handed out at clinic appointments for completion or sent to patients in the post with a return (stamped) envelope at the discretion of the clinical team. Resources for this national program were restricted.

Descriptive and regression analyses were performed using Stata v13.1[18]. Descriptive statistics were used to describe patient, clinical and tumour characteristics. Descriptive analysis was performed on 1-year oncological outcomes as event rates were too low to carry out more extensive analyses. Disease-free status was defined as disease that had achieved a complete response and not demonstrated recurrence[19] and missing data explored using logistic regression.

Exploratory analyses of EORTC QLQs and handling of missing data were performed according to EORTC guidelines, using a process of imputing missing values in scaled responses[20]. All item responses from the PROs were converted from a four-point Likert-type scale through a linear transformation onto a 0-100 scale. Higher scores for symptom items reflect more severe symptoms (i.e. 'not at all'=0; 'a little'=33.3; 'quite a bit'=66.6; 'very much'=100); higher scores for function items reflect a better level of functioning[20]. A minimum important difference (MID) was classified as a small change in scores from 5 to 10 points, moderate differences as a change up to 20 points and large differences as a change in scores of >20[21].

Mean and paired differences between baseline PRO scores and 1-year follow-up were evaluated. A two-sided t-test was used to evaluate statistical significance with a p-value <0.01 deemed to be significant, after Bonferroni correction for multiple comparisons. Multivariable linear regression analysis was performed to evaluate the impact of age, gender, acute (any) grade 3/4 toxicity, tumour stage and nodal stage on PRO items ($p<0.01$). Reasons for missing PRO data at baseline and 1-year follow up were explored using multivariable logistic regression, including age, gender, disease status, cancer centre, T stage and baseline PRO completion rates as confounders. An exploratory analysis compared mean PRO scores (for pre-defined PRO items taken from CORMAC core outcome set) at baseline and 1-year by risk groups; early stage T1/2N0 versus locally advanced T3/4 and/or N+[19, 22].

Results

Patient characteristics

1-year follow up data was collected in 40 UK Cancer Centres (71%), with numbers of participants included from each centre ranging from 1-13 participants (Median 4 per centre). Patient and tumour characteristics are summarised in Table 1 and 2 respectively. All 187 patients who received radical (curative intent) IMRT were included in this analysis, including patients who received full dose IMRT adherent to UK guidance (n=157)[6], those who received full dose IMRT not strictly adherent to UK guidance (n=23) and those receiving reduced dose IMRT (n=7) (see supplementary figure). Median radiotherapy dose received was 53.2Gy in 28 fractions(F) (Range 30-53.2Gy in 10-30F); T1/2 received median dose 50.4Gy in 28F (Range 30-54Gy in 10-30F) and T3/4 received median dose 53.2Gy in 28F (Range 40-54Gy in 15-30F). The majority of patients (n=153) completed full dose chemotherapy (n=27 dose reduced/omitted secondary to toxicity; n=7 no chemotherapy given) (see [6] for more details).

1-year survival data was available for 109 (58.2%) patients during follow-up. At 3-months no patients were known to have died. At 6-months 2 deaths were known to have occurred - both patients had residual local disease at 3-months. At 1-year, 6 patients in total had died - 94% 1-year overall survival. All 6 patients had evidence of local or distant disease, with 4 patients with residual local disease reported at 3-months. Disease-free survival status was available on 107 patients (57.2%) (2 patients were alive with unknown disease status). At 1-year, 84 were disease-free (78.5%), and 13 had local disease failure reported (5 underwent salvage surgery; 5 local regional failure; 3 LRR and metastatic disease) (12.1%). Table 3

presents 1-year oncological outcomes by patient, treatment and disease characteristics. The event rate (6 deaths) was too low to comment on any trends in the data. 86% of patients were colostomy-free at 1-year (n=97/113). In regards missing data, centres either returned oncological outcome data or did not return any.

Exploratory PRO and HRQOL analysis

A total of 121 (65%) of patients reported some PRO data at either time-point, with 115 (61%) completing at least one PRO item at baseline and 57 (30%) at 1-year. 103 (55%) had complete data across all subscales at baseline and 54 (29%) at 1-year follow up. 43 (23%) of patients have complete subscale data at both time-points. No patient, clinical or tumour characteristics predicted missing PRO data. At baseline, only cancer centre appeared to predict missing questionnaires reflecting the administration approach to PRO data collection (p=0.02). At 1-year, there were no significant predictors of missing questionnaire data.

Table 4 describes the PRO mean scores at baseline and 1-year follow-up and mean and paired differences. Pain, constipation, appetite loss, anxiety, blood and mucous in stools, and buttock pain were all significantly improved at 1-year (mean differences). On review of MID between scores at baseline and 1-year, only dyspareunia showed a moderate clinical deterioration in mean scores (14.5 to 29.5). Otherwise moderate improvements were noted for role and emotional functioning and symptom scores: pain, constipation, appetite loss, anxiety, blood and mucous in stools. A large improvement in buttock pain from baseline was reported.

In terms of 1-year toxicity, it is reassuring that there was no clinically significant deteriorations reported with PRO items on diarrhoea, bowel frequency, flatulence, urinary frequency or impotence. Mean scores at 1-year for all bowel items ranged between 19.1 to 38.8 correlating to a patient reporting a 'mild' symptom[23]. Stoma scores are not included due to low numbers of patients reporting (n=13 at baseline and n=6 at 1-year).

The sample size for sexual toxicity items was small as only 34% of women reported on symptoms (n=46) and 50% of men (n=26). However, impotence scores for men remained relatively poor (mean score 46.6 – moderate symptoms) at 1-year but did not significantly deteriorate after treatment. For women, dyspareunia showed a moderate deterioration in mean scores but overall the 1-year mean score (29.4) relates to 'mild' symptoms.

The items with the most severe symptom mean scores at 1-year were flatulence, impotence, libido (for both men and women), and health anxiety. Although, both health anxiety and female libido showed a moderate and small improvement, respectively, from baseline scores. All other changes were minor. In regards HRQOL and function, moderate improvements at 1-year were noted for role and emotional functioning.

Regression analysis on predictors of significant PRO change between baseline and 1-year found change in pain scores was predicted by gender, with women reporting less of an improvement in pain scores over time (p=0.004); and acute G3/4 toxicity, with patients reporting a greater improvement in pain scores if they had reported any G3/4 toxicity during treatment or if this data was unknown as compared to patients with no G3/4 toxicity

(p=0.007). Similarly, change in buttock pain scores found women reporting less improvement in pain over time (p=0.01).

The exploratory analysis by risk groups (supplementary file), found locally advanced tumours have poorer baseline scores but report relatively greater improvements in function and cancer symptoms. In comparison, patients with early stage tumours are less compromised by cancer-related issues at baseline but have a proportionally greater change in scores by 1-year representing more toxicity-related issues.

Discussion

To our knowledge this is the largest, multicentre prospective cohort of 1-year oncological outcomes including PRO assessment of anal cancer patients treated with curative intent IMRT. The results provide a comprehensive evaluation of patients treated in routine practice in the UK.

The 1-year oncological outcomes found patients to have reassuringly high overall (94%), disease-free (84%) and colostomy-free (86%) survival in line other prospective studies of IMRT and randomised studies of conformal radiotherapy in anal cancer[2, 9, 24].

The toxicity rates for all symptoms are generally low and improvements in disease-related symptoms, such as buttock pain and per rectal bleeding, significant. Importantly at 1-year, there were no significant deteriorations seen in bowel toxicity items including diarrhoea, bowel frequency, and flatulence, although flatulence symptom scores remained moderately

severe (40.2). Urinary symptoms also did not significantly deteriorate at 1-year, although studies of pelvic radiotherapy with longer follow up have found that whilst bowel symptoms may improve after 1-year, urinary symptoms may deteriorate over a longer timeframe[26]. Whilst the sample for patients reporting on sexual function is small, it is important to note that dyspareunia deteriorated moderately at 1-year; and impotence symptom scores remained moderately severe, with a relatively greater deterioration seen in earlier cancers.

The 1-year PRO toxicity scores are similar to those reported in single-centre series of patients treated with IMRT[9, 27]. Although the use of different questionnaires and quality of reporting can make it challenging to directly compare results with other studies, the rates of late toxicity for bowel and erectile function using IMRT appear to be lower than cross-sectional series of patients treated with conformal techniques[28-31]. These findings are likely to reflect the sculpted dose around bowel and penile bulb structures resulting in reduced dose anteriorly[32]. For example, within the current study at 1-year patients reported mild diarrhoea symptoms (mean 16.4; SD22.0). Similarly, contemporary studies of patients treated with IMRT report mild symptoms with mean scores ranging from 12-22.8[9, 27]. In comparison, older studies have reported moderate diarrhoea symptom scores with mean scores between 27-34.6[28, 30, 31, 33]. Similarly, large to moderate improvements using IMRT are observed with symptoms of flatulence, faecal incontinence and impotence[27, 30, 31]. Our rates of dyspareunia, urinary frequency and incontinence were similar to results from previous conformal and IMRT studies. Vaginal doses remain high as the structure is directly adjacent to the high dose tumour volume, whilst bladder symptoms may be more reflective of pre-morbid symptoms as minimal change was observed from baseline[34, 35].

The exploratory analysis lends credence to the need to improve symptoms with a significant impact on QOL, such as flatulence, dyspareunia and impotence, and this should be a target for future studies de-escalating dose in patients with low-risk anal cancer[22]. Indeed, these data provide a benchmark to test improvements in PRO from reduced dose IMRT in early stage disease and to assess any potential 'cost' in PRO from efforts to improve locoregional control in advanced disease with increasing radiotherapy doses, as is being tested in the ongoing platform trial, PLATO (personalizing anal cancer radiotherapy dose; registry no. ISRCTN88455282)[22].

Due to the restricted resources available for national programs, there are missing data for both PRO and oncological outcomes, more so at 1-year follow-up. The event rate therefore could be underestimated although PRO scores and oncological event rates were similar to expected. This demonstrates the limitations of unfunded multi-centre national audit programs. However, it is reassuring than no patient, clinical or tumour characteristics appeared to predict missing data. Only centres failing to return data appears to be in effect, which provides a strong argument in support of the reliability of these results. The authors also acknowledge that 1-year is an early timepoint in follow-up. A further limitation is standardised quality assurance for IMRT implementation and delivery. At the time of patient recruitment, no validated anal cancer specific PRO existed and therefore as in other studies, the EORTC-QLQ CR29 was used for evaluation. Whilst this provides good quality data, a number of important long-term toxicity issues are missing; of particular note, symptoms related to bowel urgency, toilet dependency, and vaginal symptoms such as vaginal dryness and stenosis. These issues are present in the newly developed EORTC-QLQ ANL27, which is

currently under phase IV international validation testing and included in the PLATO trial[17, 36]. Future studies should use the EORTC-QLQ ANL27 to provide an accurate understanding of patient disease and toxicity burden [37] and prioritise a priori selection of key PRO items highlighted in CORMAC, the anal cancer core outcome set, for hypothesis testing[19].

Conclusions

In comparison to other studies reporting PRO and HRQOL in anal cancer, our study provides PRO data in a multicentre prospective setting. The effective implementation of IMRT in a national setting was reported previously[6]. At 1-year, early oncological outcomes were reassuring and result in good disease-related symptom control measured with PROs. In comparison to historical series of conformal radiotherapy, these results also suggest benefits in the reduction of bowel and male sexual dysfunction at 1-year. These findings, as well as providing prospective PRO toxicity data to better understand patient experience, may also provide the basis for benchmarking future studies.

Conflict of Interest statement

None declared

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Table

Table 1: Patient characteristics and 1-year outcomes

Patient characteristics	Number of patients (n=187)	%
Median age in years (range)	61 (29-90)	
Gender		
Female	135	72.2
Male	52	27.8
T/N stage*		
T1/2N0	65	34.8
T1/2N+	33	17.6
T3/4N0	29	15.5
T3/4N+	58	31.0
Tx	2	1.1
Smoking status		
Current smoker	41	21.9
Non-smoker	109	58.3
Unknown	37	19.8
HIV status		
HIV negative	73	39.0
HIV positive	7	3.7
Test not performed	107	57.2
Disease status at 1 year (n=109)		
Disease free	84	77.1
Local regional recurrence/failure	13	11.9
Metastatic disease	5	4.6
Dead	6	5.5
Alive unknown disease status	2	1.8
Self-reported stoma status at 1 year (n=113)		
Stoma free	97	85.8
Stoma present	16	14.2

* M1 (n=4): All treated with curative intent IMRT; *n=1 low paraaortic lymph node and n=1 perineal satellite nodule (encompassed within RT volume); n=1 solitary lung metastasis removed surgically; n=1 no data available on detail of metastatic disease at presentation or at 1-year follow up*

Table 2: Treatment characteristics and PRO completion

Treatment characteristics	Number of patients (n=187)	%
Radiotherapy technique		
IMRT	81	43.3
Tomotherapy	30	16.0
VMAT / IMAT	76	40.6
Chemotherapy regime		
Mitomycin 5FU	114	61.0
MMC Capecitabine	58	31.0
Other	8	4.3
No chemotherapy	7	3.7
Any G3/4 toxicity		
No G3/4 toxicity	74	39.6
Any G3/4 toxicity	77	41.2
Unknown	36	19.3

PRO completion	Number of patients (n=187)	%
Baseline PRO completion*		
Yes	115	61.5
No	72	38.5
1-year PRO completion*		
Yes	57	30.5
No	130	69.5

* At least one item completed on PRO questionnaires

Table 3: 1-year oncological outcomes

	Alive N=103 (%)	Dead at 1 year N=6 (%)	Total N (%)
Gender			
Female	73 (97.3%)	2 (2.7%)	75 (100%)
Male	30 (88.2%)	4 (11.8%)	34 (100%)
Age at start of RT			
<=62	47 (92.2%)	4 (7.8%)	51 (100%)
>62	56 (96.6%)	2 (3.4%)	58 (100%)
T Stage			
T1/2	60 (98.4%)	1 (1.6%)	61 (100%)
T3/4	41 (89.1%)	5 (10.9%)	46 (100%)
Tx	2 (100%)	0 (0.0%)	2 (100%)
N Stage			
Node negative	55 (96.5%)	2 (3.5%)	57 (100%)
Node positive	48 (92.3%)	4 (7.7%)	52 (100%)
Concurrent chemotherapy			
MMC and 5FU	57 (95.0%)	3 (5.0%)	60 (100%)
MMC and Capecitabine	40 (95.2%)	2 (4.8%)	42 (100%)
None	2 (66.7%)	1 (33.3%)	3 (100%)
Other	4 (100%)	0 (0.0%)	4 (100%)
Radiotherapy technique			
IMRT	45 (95.7%)	2 (4.3%)	47 (100%)
Tomotherapy	11 (100%)	0 (0.0%)	11 (100%)
VMAT / IMAT	47 (92.2%)	4 (7.8%)	51 (100%)
Smoking Status			
Current smoker	14 (77.8%)	4 (22.2%)	18 (100%)
Ex/never smoked	66 (98.5%)	1 (1.5%)	67 (100%)
Unknown	23 (95.8%)	1 (4.2%)	24 (100%)

Table 4: PRO scores at baseline and 1-year follow up, clinical significance in score change, mean and paired differences

	Baseline	1 year follow-up	Significance ¥	Mean differences‡	t-value	Probability (two tailed)	Paired differences[δ]	t-value	Probability (two tailed)
EORTC-QLQ C30									
FUNCTION: higher scores = improved function (0-100)									
Global health status§									
Mean (s.d.)	64.0 (25.3)	72.8 (19.5)	**I-S**	8.9 (1.17, 16.6)	2.27	0.02	-0.37 (-7.03, 6.29)	-0.11	0.91
N	106	55		df 159			45		
Physical functioning§									
Mean (s.d.)	81.1 (22.3)	84.0 (20.7)	**I-T**	2.9 (-4.11, 9.92)	0.81	0.42	-7.19 (-12.8, -1.54)	-2.56	0.01*
N	110	57		df 165			46		
Role functioning§									
Mean (s.d.)	70.9 (32.1))	81.0 (24.1)	**I-M**	10.1 (0.58, 19.7)	2.09	0.04	2.12 (-7.69, 11.9)	0.43	0.66
N	111	57		df 166			47		
Emotional functioning§									
Mean (s.d.)	69.5 (25.6)	80.3 (23.1)	**I-M**	10.8 (2.68,19.0)	2.62	0.01*	5.06 (-2.83, 12.9)	1.29	0.20
N	106	55		df 159			45		
Cognitive functioning§									
Mean (s.d.)	78.8 (22.6)	84.8 (20.9)	**I-S**	6.07 (-1.15, 13.3)	1.65	0.10	3.33 (-2.37, 9.04)	1.17	0.24
N	106	55		df 159			45		
Social functioning§									
Mean (s.d.)	72.9 (30.5)	76.6 (27.1)	**I-T**	3.41 (-5.95, 13.3)	0.75	0.44	-4.07 (-12.0, 3.85)	-1.03	0.30
N	106	55		df 159			45		
SYMPTOMS: higher scores = worse symptoms (0-100)									
Fatigue									
Mean (s.d.)	33.6 (29.3)	26.2 (22.8)	**I-S**	-7.39 (-16.2, 1.46)	-1.64	0.10	0.23 (-7.19, 7.66)	0.06	0.94
N	110	56		df 164			47		

	Baseline	1 year follow-up	Significance ¥	Mean differences‡	t-value	Probability (two tailed)	Paired differences[δ]	t-value	Probability (two tailed)
Nausea and vomiting									
Mean (s.d.)	9.6 (20.0)	4.09 (10.5)	**I-S**	-5.51 (-11.1, 0.09)	-1.94	0.05	-1.41 (-4.92, 2.09)	-0.81	0.42
N	111	57		df 166			47		
Pain									
Mean (s.d.)	32.0 (32.2)	15.5 (23.7)	**I-M**	-16.5 (-26.1, -6.9)	-3.39	0.001*	-9.21(-18.5, 0.06)	-1.99	0.05
N	111	56		df 165			47		
Dyspnoea									
Mean (s.d.)	12.3 (23.0)	14.0 (23.3)	**D-T**	1.68 (-5.91, 9.28)	0.43	0.66	6.38 (-2.18, 14.9)	1.49	0.14
N	108	57		df 163			47		
Insomnia									
Mean (s.d.)	33.9 (31.4)	25.7 (30.8)	**I-S**	-8.2 (-18.2, 1.85)	-1.61	0.11	-5.67 (-14.8, 3.52)	-1.24	0.22
N	111	57		df 166			47		
Appetite loss									
Mean (s.d.)	21.8 (30.4)	8.9 (19.5)	**I-M**	-12.9 (-21.7, -4.05)	-2.88	0.005*	-5.79 (-12.8, 1.21)	-1.66	0.10
N	110	56		df 164			46		
Constipation									
Mean (s.d.)	26.7 (34.4)	9.9 (18.8)	**I-M**	-16.8 (-26.5, -7.1)	-3.41	0.0008*	-14.1 (-23.7, -4.66)	-3.00	0.004*
N	111	57		df 166			47		
Diarrhoea									
Mean (s.d.)	20.1 (31.0)	18.2 (22.9)	**I-T**	-1.9 (-11.3, 7.4)	-0.41	0.68	3.70 (-7.63, 15.0)	0.65	0.51
N	106	55		df 159			45		
Financial problems									
Mean (s.d.)	22.0 (33.1)	16.3 (23.8)	**I-S**	-5.64 (-15.5, 4.30)	-1.12	0.26	2.22 (-5.87, 10.3)	0.65	0.51
N	106	55		df 159			45		

	Baseline	1 year follow-up	Significance ¥	Mean differences‡	t-value	Probability (two tailed)	Paired differences[δ]	t-value	Probability (two tailed)
EORTC-QLQ C29									
FUNCTION: higher scores = improved function (0-100)									
Body Image§									
Mean (s.d.)	76.7 (28.7)	76.0 (28.9)	**D-T**	-0.69 (-10.0, 8.62)	-0.14	0.88	-5.81 (-13.4, 1.85)	-1.52	0.13
N	112	56		df 166			43		
Health anxiety§									
Mean (s.d.)	46.8 (33.1)	60.7 (29.2)	**I-M**	13.9 (3.6, 24.2)	2.68	0.008*	12.5 (0.64, 24.5)	2.12	0.03
N	114	56		df 168			45		
Weight worries§									
Mean (s.d.)	77.4 (30.8)	75.5 (29.4)	**D-T**	-1.89 (-11.6, 7.91)	-0.38	0.70	-2.27 (-12.3, 7.83)	-0.45	0.65
N	114	56		df 168			44		
Male libido (sexual interest)§									
Mean (s.d.)	32.0 (30.5)	28.8 (27.7)	**D-T**	-3.16 (-22.5, 16.2)	-0.32	0.74	-3.81e-07 (-29.7, 29.7)	0.00	1.00
N	26	15		df 39			10		
Female libido (sexual interest)§									
Mean (s.d.)	12.2 (23.6)	18.9 (26.6)	**I-S**	6.63 (-3.15, 16.4)	1.34	0.18	5.437 (-7.28, 18.0)	0.86	0.39
N	76	37		df 111			31		
SYMPTOMS: higher scores = worse symptoms (0-100)									
Urinary frequency									
Mean (s.d.)	38.1 (26.0)	32.7 (22.0)	**I-S**	-5.4 (-13.4, 2.6)	-1.33	0.19	2.22 (-5.66, 10.1)	0.56	0.57
N	115	56		df 169			45		
Blood/Mucous in stools									
Mean (s.d.)	24.8 (26.1)	14.6 (17.9)	**I-M**	-10.2 (-17.9, -2.5)	-2.63	0.009*	-8.51 (-15.8, -1.15)	-2.33	0.02
N	115	56		df 169			45		
Bowel Frequency									
Mean (s.d.)	19.9 (19.4)	20.0 (20.9)	**D-T**	0.08 (-7.3, 7.4)	0.02	0.98	3.33 (-6.36, 13.0)	0.69	0.48
N	82	45		df 125			35		

	Baseline	1 year follow-up	Significance ¥	Mean differences‡	t-value	Probability (two tailed)	Paired differences[δ]	t-value	Probability (two tailed)
Urinary incontinence									
Mean (s.d.)	9.1 (20.4)	13.1 (21.7)	**D-T**	4.03 (-2.7, 10.8)	1.18	0.24	8.33 (1.37, 15.2)	2.41	0.02
N	114	56		df 168			44		
Dysuria									
Mean (s.d.)	9.27 (22.7)	2.97	**I-S**	-6.29 (-12.5,-0.03)	-1.98	0.04	-3.70 (-9.02, 1.62)	-1.40	0.16
N	115	56		df 169			45		
Abdominal pain									
Mean (s.d.)	12.7 (23.4)	9.52 (18.7)	**I-T**	-3.20 (-10.3, 3.92)	-0.88	0.37	-1.55 (-7.45, 4.35)	-0.53	0.59
N	110	56		df 164			43		
Buttock pain									
Mean (s.d.)	45.6 (36.0)	23.3 (25.3)	**I-L**	-22.4 (-33.0, -11.8)	-4.16	0.0001*	-12.5 (-25.4, 0.26)	-1.97	0.05
N	114	56		df 168			45		
Dry mouth									
Mean (s.d.)	28.2 (34.4)	23.2 (32.9)	**I-S**	-5.05 (-16.0, 5.91)	-0.91	0.36	-3.03 (-15.1, 9.10)	-0.50	0.61
N	112	56		df 166			44		
Hair loss									
Mean (s.d.)	2.97 (13.4)	5.3 (13.8)	**D-T**	2.38 (-2.08, 6.85)	1.05	0.29	2.17 (-4.41, 4.41)	0.00	1.00
N	101	56		df 155			38		
Taste change									
Mean (s.d.)	12.0 (26.7)	10.1 (24.5)	**I-T**	-1.91 (-10.3, 6.54)	-0.44	0.65	2.43 (-5.84, 10.7)	0.59	0.55
N	108	56		df 162			41		
Flatulence									
Mean (s.d.)	36.1 (30.7)	40.2 (28.3)	**D-T**	4.04 (-7.0, 15.1)	0.73	0.47	6.66 (-5.37, 18.7)	1.12	0.26
N	84	44		df 126			35		
Faecal incontinence									
Mean (s.d.)	17.9 (25.7)	19.3 (27.0)	**D-T**	1.4 (-8.3, 11.0)	0.28	0.78	5.71 (-6.85, 18.2)	0.92	0.36
N	82	45		df 125			35		

	Baseline	1 year follow-up	Significance ¥	Mean differences‡	t-value	Probability (two tailed)	Paired differences$^{\delta}$	t-value	Probability (two tailed)
Anal sore skin									
Mean (s.d.)	29.7 (31.1)	22.7 (30.3)	**I-S**	-6.90 (-18.3, 4.54)	-1.19	0.23	-0.98 (-13.7, 15.7)	0.13	0.89
N	81	55		df 123			34		
Bowel embarrassment									
Mean (s.d.)	19.6 (27.9)	25.2 (31.9)	**D-S**	5.6 (-5.2, 16.4)	1.02	0.31	9.52 (-2.76, 21.8)	1.57	0.12
N	80	45		df 123			35		
Impotence									
Mean (s.d.)	37.2 (43.5)	46.7 (39.4)	**D-S**	9.5 (-18.1, 37.1)	0.69	0.49	-6.66 (-46.8, 33.5)	-0.37	0.71
N	26	15		df 39			10		
Dyspareunia									
Mean (s.d.)	14.5 (27.8)	29.5 (38.0)	**D-M**	15.0 (-0.6, 30.6)	1.92	0.06	17.9 (0.28, 35.6)	2.21	0.04
N	46	26		df 70			13		

§ Function scores: higher scores = improved function; * P-values with <0.01 significance; ‡Unpaired t-test; $^{\delta}$Paired t-test; ¥ Significance - D deterioration; I improvement; S small (5-10); M moderate (10-20); L large (>20); T Trivial (<5)

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Supplementary Figure (online publication only)

Supplementary data

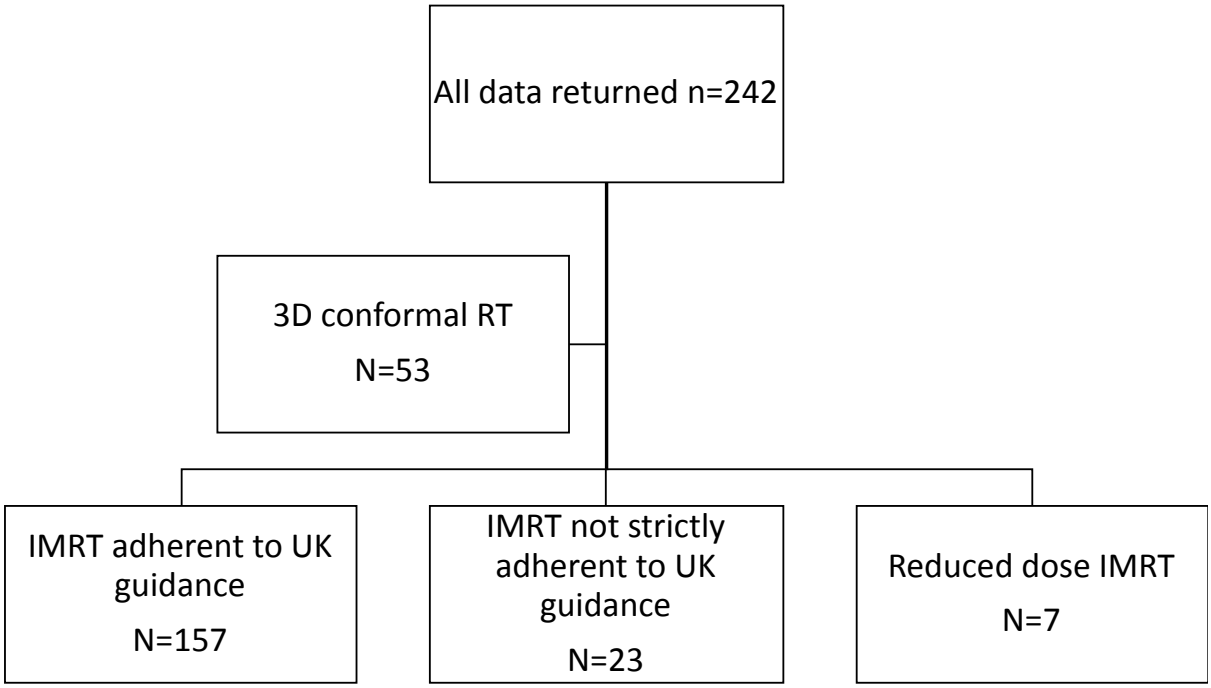

Figure 1: Flowchart clarifying data included in publication

CORMAC Core Outcome Set outcomes by Early and Advanced risk groups

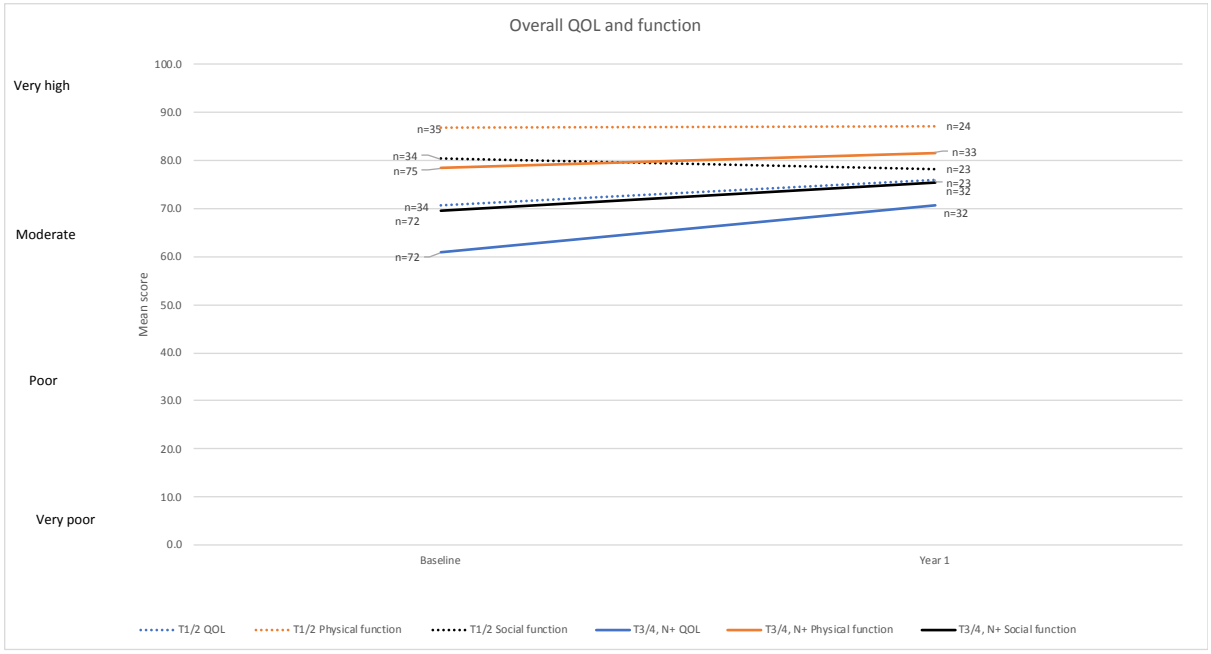

Figure 2: Overall QOL and function by Early vs Advanced cancer grouping

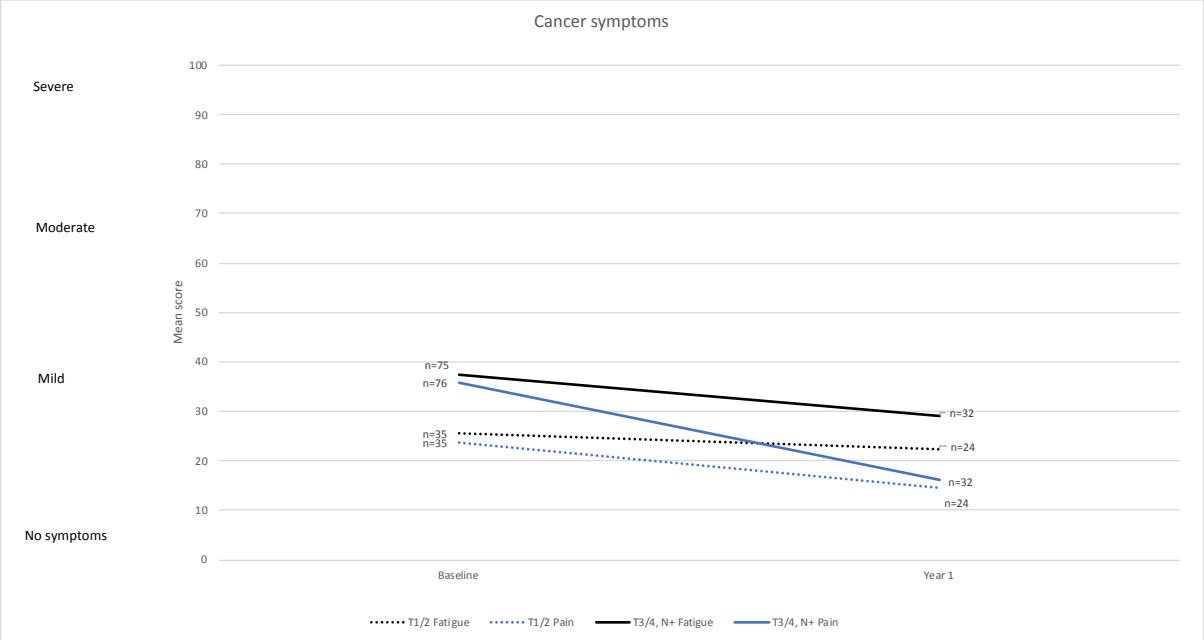

Figure 3: Cancer symptoms by Early vs Advanced cancer grouping

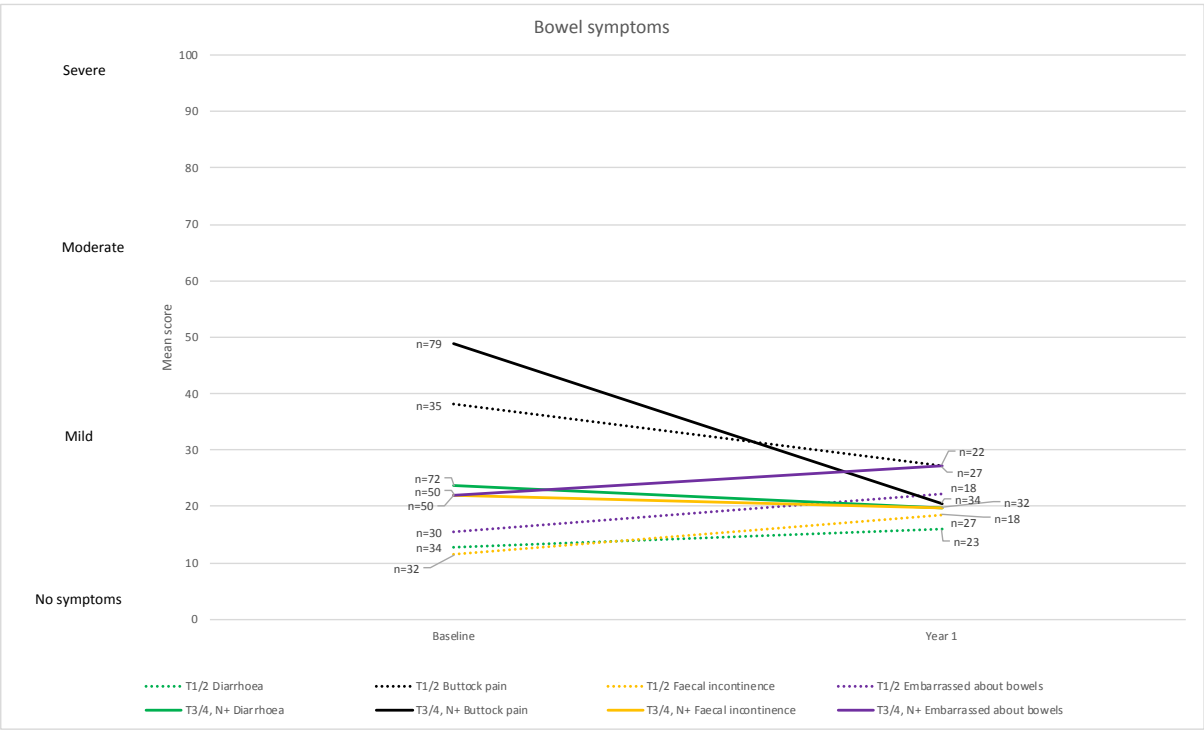

Figure 4: Bowel Symptoms by Early vs Advanced cancer grouping

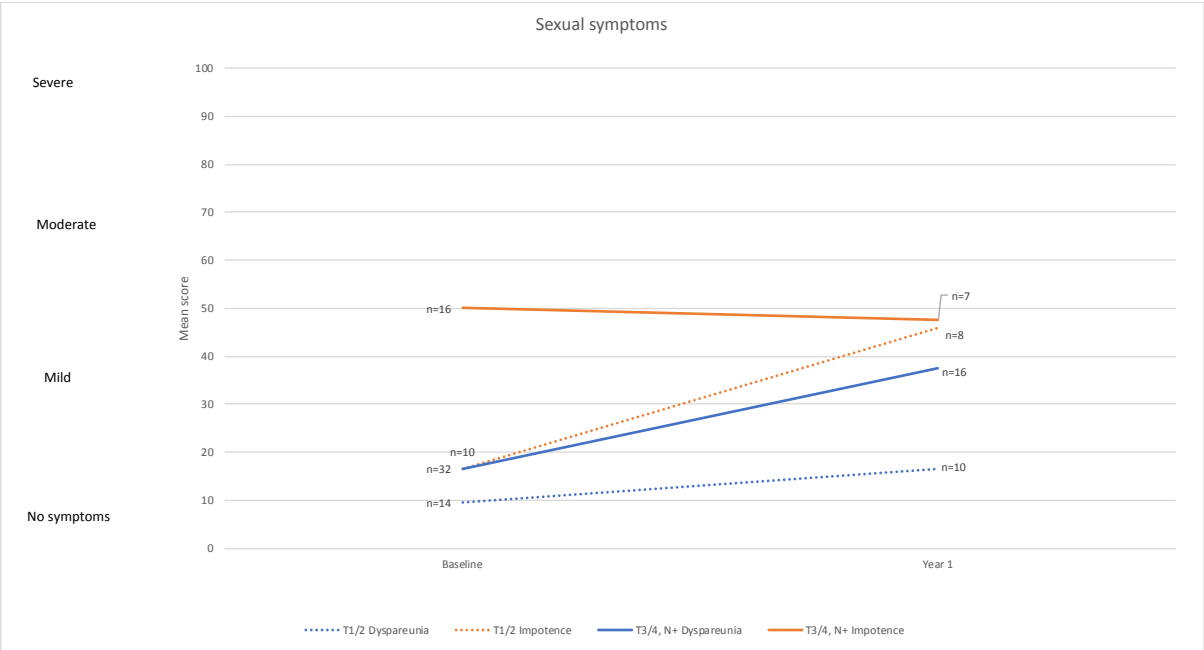

Figure 5: Sexual symptoms by Early vs Advanced cancer grouping

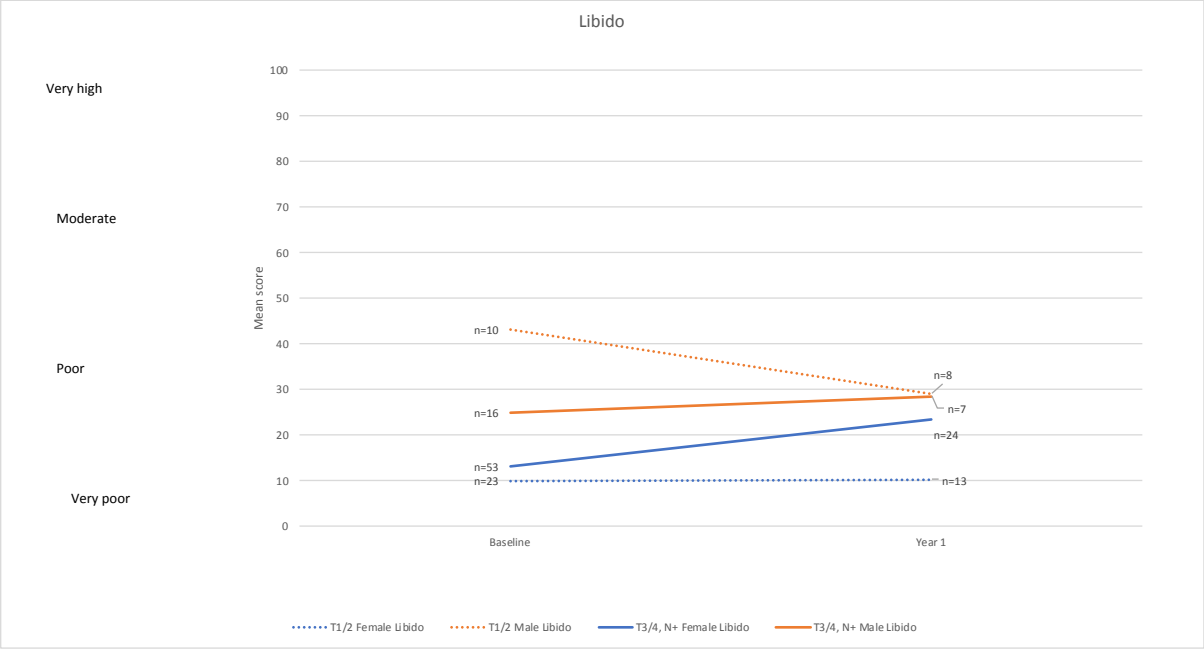

Figure 6: Libido by Early vs Advanced cancer grouping