SPIDERplan: A tool to support decision making in radiation therapy treatment plan assessment

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ABSTRACT

Aim: In this work, a graphical method for radiotherapy treatment plan assessment and com-parison, named SPIDERplan, is proposed. It aims to support plan approval allowing indepen-dent and consistent comparisons of different treatment techniques, algorithms or treatment planning systems.
Background: Optimized plans from modern radiotherapy are not easy to evaluate and com-pare because of their inherent multicriterial nature. The clinical decision on the best treatment plan is mostly based on subjective options.
Materials and methods: SPIDERplan combines a graphical analysis with a scoring index. Customized radar plots based on the categorization of structures into groups and on the determination of individual structures scores are generated. Toeach group and structure, an angular amplitude is assigned expressing the clinical importance defined by the radiation oncologist. Completing the graphical evaluation, a global plan score, based on the structures score and their clinical weights, is determined. After a necessary clinical validation of the group weights, SPIDERplan efficacy, to compare and rank different plans, was tested through a planning exercise where plans had been generated for a nasal cavity case using different treatment planning systems.
Results: SPIDERplan method was applied to the dose metrics achieved by the nasal cavity test plans. The generated diagrams and scores successfully ranked the plans according to the prescribed dose objectives and constraints and the radiation oncologist priorities, after a necessary clinical validation process.

Keywords: Plan approval support ; Plan scoring; Treatment planning; Radiation therapy

1. Background

Radiotherapy is a treatment cancer modality that has as main purpose to eliminate tumour cells in a controlled way through radiation, while sparing as much as possible adjacent normal tissues. Each treatment session is delivered according to an optimized plan generated by a treatment planning system (TPS). The selection of the plan whose dose distribution better fulfils the medical prescription is not a trivial task. Visual inspection of the 3D dose distribution, a detailed analysis of the dose statistics and dose volume histograms (DVH) generated for each structure are the most common tools to assess the quality of the plan. To assist the radiation oncologist in plan selection, several graphical solutions, such as the superposition of DVH and dose distributions or the side-by-side plan comparison, have been made available in commercial TPSs. The large and diverse amount of data to be analyzed, generally with conflicting results, makes plan selection hard and time-consuming. Final clinical decision is then made by the radiation oncologist mostly based on a subjective and qualitative assessment of the planned dose distributions taking into account only the most important features of the plan.[1] Optimal balance between the probability of tumour control and normal tissues complications is thus not guaranteed moreover when multiple plans are available for final clinical decision. Quantifying plan quality taking into account both the coverage of target volumes and the sparing of all organs-at-risk (OAR) in a simple and objective way has always been an ideal aim in the treatment planning process for helping the final clinical decision. First attempts have been proposed based on statistical decision theory,[2] multiattribute utility theory[3] and decision analysis concepts[3] for application to 3D conformal radiotherapy. However, they have never been incorporated in optimization algorithms nor implemented in treatment planning systems.

On the other hand, dose-quality treatment indexes have been considered a valuable contribution for plan assessment. Since the 1990s, several indexes have been reported for external radiotherapy.[4–20] Target coverage and conformity indexes are the most common options. Target coverage index, known as RTOG index, first proposed by Shaw et al.[4] for radiosurgery treatment plans was intended to measure the ratio of the minimum isodose to the prescribed dose in the planning target volume (PTV). Despite its simplicity, the coverage index yields false positives and is extremely dependent of the selected reference isodose. A different coverage target score was proposed by the SALT group[5,6] and by Lomax and Scheib.[7] Based on a volumetric concept, this approach solves the previous drawbacks, but as for the RTOG index, it still does not take into account dose in the healthy tissues. Conformity indexes focus on the relation between the shape of the reference isodose and the PTV. Although the first conformity index types were developed for the evaluation of radiosurgery plans, Knöös et al.[9] extended this definition to breast, lung, prostate and head-and-neck pathologies. Simple as they are, these indexes neither consider the dose received by the normal tissues nor distinguish spatial mismatches between the target volume and the reference dose volume. Lomax and Scheib[7] presented a conformity index definition that includes the quantification of the irradiation of healthy tissues. To avoid false positives, this index should be reported together with the target coverage index also proposed by Lomax and Scheib.[7] The conformation number (CN), proposed by van't Riet et al.[10] and Paddick,[11] intended to assess the conformity of a radiosurgery plan, quantifying target coverage and normal tissues exposure. However, the CN score does not take into account the different OAR tolerances, considering all non-tumour tissues as a single critical structure with the same radiosensitivity. This was partially solved by the COIN score, initially developed for brachytherapy plans.[12] The COIN added to the CN expression a penalty factor for the unwanted doses in the OAR. As the dose values used in the score calculation are not adjusted to the tolerance level of each structure, a new index called critical organ scoring index (COSI) was proposed.[13] The COSI index allows a simultaneous quantification of target coverage and dose irradiation of OARs. To get information about plan conformity, the COSI index must be represented in a 2D diagram against the conformity index proposed by Lomax and Scheib.[7] The inclusion of both target coverage and OAR affectation into CN, COIN and COSI definitions leads to a loss of information allowing that different dose distributions may present the same index values.

Based on the radiosurgery quality indexes, new score definitions applicable to all radiotherapy modalities have been published, namely for intensity modulated radiation therapy (IMRT) plans. Due to their comprehensive definition and applicability, the uncomplicated target conformity index (TCI^+),[14] the conformity index incorporating dose and distance (CI_{DD}),[15] the plan quality index (PQI),[16] and the composite quality index (CPQI)[17] are the most representative scores. The TCI^+, suggested by Miften et al.,[14] includes adjustable penalty functions evaluating target conformity and OARs sparing. Despite the good results, the sensitivity of the parameters of the penalty function depends on the clinical experience and the accuracy of the clinical tolerance data. A similar approach was proposed by Cheung and Law[15] with the CI_{DD}. In addition to the target coverage factor, this score also incorporates a target underdosage factor that presents a penalty function dependent on the value and localization of the cold spot. Nevertheless, the CI_{DD} neither quantifies the normal tissue sparing nor the conformity of the dose distribution to the target. The PQI developed by Leung et al.[16] incorporates multiple plan evaluation scores. Applying the Euclidean distance definition to the conformity of PTVs with different dose levels, target coverage and normal tissue sparing are assessed.

The PQI index also includes a quantification of the cold and hot spots in the target coverage parameter. The normal tissue score includes a penalty function that allows the evaluation of different tolerance point criteria. More recently, the composite quality index or CPQI[17] combined the target coverage, the homogeneity index, the equivalent uniform dose (EUD),[21,22] tumour control probability (TCP) and the normal tissue complication probability (NTCP) applying to each a relative weight. Plan quality indexes are a promising solution for treatment plan evaluation. However, due to their definition or complexity, these tools were never widely adopted in clinical practice.

Using a completely different approach, alternative solutions for treatment plan evaluation may be based on radiobiological functions. TCP, NTCP and the probability of uncomplicated tumour control[23] are examples of radiobiological measures that may estimate the outcome of a treatment plan. However, nowadays, the benefits that could be achieved with this approach are still overshadowed by the uncertainty associated with the variables needed during the biological modelling process.

With the implementation of inverse treatment planning optimization, a variety of objective functions were implemented into TPSs to drive the optimization algorithm in each iteration. The score corresponding to the value of the objective function should ideally be correlated with the quality of the dose distribution and, thus, the final plan would represent the optimal radiation treatment. Nevertheless, this is generally a pure mathematical expression without clinical relevance. Furthermore, a strict comparison between plans optimized in different treatment planning systems is only valid when the same objective function is used. Comparisons between different optimization algorithms are thus not generally made simply based on the final value of the objective function.

2. Aim

In this study a plan quality assessment tool called SPIDERplan is proposed. This tool intends to evaluate the quality of different plans using an intuitive graphic representation and an associated score function. These are based on the target and normal tissues objectives/constraints defined by the radiation oncologist and are completely independent of the algorithm, the treatment technique or the TPS. Without any ambition to correlate this score with treatment outcome, SPIDERplan aims to be a supporting tool to help during clinical decision-making in consistently selecting the best treatment plan available.

3. Material and methods

3.1. *SPIDERplan concept description*

SPIDERplan is a graphical method developed to assess and compare the quality of different radiotherapy treatment plans. Based on a scoring approach, both target coverage and individual OAR sparing are considered, allowing the quantification of the global quality of any treatment planning modality. This method can be described in two phases: 1) processing of the plan data and 2) assessment of plan quality. The outputs for plan evaluation are graphs and scores that provide the user with a fast and intuitive image of plan(s) quality. Clinical validation to fine tune SPIDERplan input variables is necessary before using it in clinical practice.

In phase one, processing of the plan data, targets and OARs are divided into groups (e.g. optical track group, including organs like optic nerves and chiasm). Each structure has an assigned score based on planning objectives that may be either dosimetric, volumetric, radiobiological or mathematical. This score is a scalar that expresses the performance of that structure in accomplishing the corresponding planning goal. A pre-defined relative weight is also attributed to each group and to each structure expressing the clinical priorities during the plan evaluation process. The definition of these groups and weights must be customized by the local clinical team according to the tumour type prior to the clinical use of SPIDERplan. The numerical weighs reflect the relative importance given by the radiation oncologist to the different planning aims. Similarly, the grouping of the different structures strongly depends on the tumour type and morphology and must reflect the relative importance the physician will give to the different structures when he/she will appreciate the dose distributions. Thus, SPIDERplan is completely designed for each tumour type according to the radiation oncologist's preferences.

In phase two, assessment of plan quality, all this information is graphically represented in customized radar plots. Evaluation of plan quality can be done globally visualizing all structures and groups' information or in more detail assessing each group analysis in partial radar plots. For the global analysis mode, where all structures are considered, a radar plot named Structures Plan Diagram (SPD) is generated. The circular plotting area is divided into sections and subsections with an angular amplitude proportional to the relative weight of the respective group and structure. The score of each structure is represented by a point along the angle bisector of the respective subsection whose distance from the centre of the radar plot corresponds to the score value. By connecting the score of all structures a polygon representing the quality of the dose distribution is generated. Global plan score is determined as a weighted sum of the structures individual scores across all groups as:

$$\text{Global plan score} = \sum_i \sum_j w_{\text{group(i)}} w_{\text{struct(j)}} Score_{\text{struct(j)}} \quad (1)$$

where $w_{\text{struct(j)}}$ and $Score_{\text{struct(j)}}$ are the relative weight and the score of structure j, respectively, and $w_{\text{group(i)}}$ is the relative weight of group i.

The SPD information may also be condensed by groups of structures. In this option the radar plot is called Group Plan Diagram (GPD), where it is designed for the groups instead of the structures. A more detailed group evaluation can also be done with the partial group plots. The group plots are named Structures Group Diagrams (SGD). Only the structures of a particular group are then represented. As for the SPD and GPD, a partial group score complementing the graphical assessment is determined for each SGD.

3.2. *Application to a clinical case*

To assess SPIDERplan ability to compare and rank radiotherapy plans, an already treated nasal cavity clinical case was selected and re-planned in iPlan RT Dose version 4.5 from BrainLAB. IMRT technique was based on an m3 micro multileaf collimator (mMLC) from BrainLAB. For inverse optimization, this TPS generates three IMRT plans with different OAR priorities: low, medium and high. Irradiation technique used eight non-coplanar beams composed of 15 segments. Dose calculation was done by applying a Pencil Beam algorithm and a dose grid of $1 \times 1\,mm^2$.

SPIDERplan independence from TPS and dose calculation algorithms were assessed by comparing iPlan plans with a plan generated in Oncentra version 4.1 SP2 optimizer module from Elekta for the same clinical case. The Oncentra IMRT plan was generated using a Siemens 82-leaf Optifocus multileaf collimator (MLC). Collapsed Cone algorithm with a dose grid of $1 \times 1\,mm^2$ was applied to optimize 9 beams delivering 100 segments.

A dose of 60 Gy delivered in 30 fractions was prescribed to the PTV. The main considered OARs were lens, retinas, chiasm, optical nerves, pituitary gland, brainstem, cochlea, parotids and oral cavity. The respective tolerance doses values, shown in Table 1, were established in agreement to the institutional protocols defined for this pathology.

Structures were grouped into PTV group, Optics group and Other group, Table 1. These groups were defined according to structures localization and clinical importance for the pathology concerned. The PTV group just comprised the PTV. The Optics group was constituted by all the optical structures: lens, optical nerves, retinas and chiasm, which were next to the PTV and so acted as critical structures for planning. The Other group included all other structures that were distant from the PTV or whose tolerance dose values were not critical for this particular planning context: brainstem, pituitary gland, cochlea, parotids and oral cavity (Fig. 1). This grouping reflects the relative importance that the radiation oncologist gives to the different structures when appreciating different treatment options.

Table 1 – Groups and structures considered for SPIDERplan processing.

Groups	Structures	
Name	Name	Tolerance criteria
PTV group	PTV	$D_{98\%} \geq 95\%$ of 60 Gy
Optics group	Chiasm	$D_{max} \leq 50$ Gy
	Left optical nerve (OPTNRVL)	$D_{max} \leq 50$ Gy
	Right optical nerve (OPTNRVR)	$D_{max} \leq 50$ Gy
	Left retina (RETINAL)	$D_{max} \leq 45$ Gy
	Right retina (RETINAR)	$D_{max} \leq 45$ Gy
	Left lens (LENSL)	$D_{max} \leq 12$ Gy
	Right lens (LENSR)	$D_{max} \leq 12$ Gy
Other group	Brainstem	$D_{max} \leq 54$ Gy
	Pituitary gland (PITUITARY)	$D_{max} \leq 60$ Gy
	Left cochlea (COCHLEAL)	$D_{mean} \leq 45$ Gy
	Right cochlea (COCHLEAR)	$D_{mean} \leq 45$ Gy
	Oral cavity (ORALCAVITY)	$D_{mean} \leq 45$ Gy
	Left parotid (PAROTIDL)	$D_{mean} \leq 26$ Gy
	Right parotid (PAROTIDR)	$D_{mean} \leq 26$ Gy

The score of each structure may be determined by any function locally used to evaluate plan quality. This study used a score based on the ratio between clinical tolerance criteria and the planned dose. Thus, a value of one is expected if the dose for that structure is equal to the respective tolerance value. When a better organ sparing or target coverage is achieved, a score less than one will be obtained. In the SPIDERplan diagrams, this becomes easily perceived by the relation obtained with two circles: the inner circle with unitary radius representing the limit of acceptability and the outer circle with radius equal to two representing failures. Optimal scores will converge to the radar plot centre.

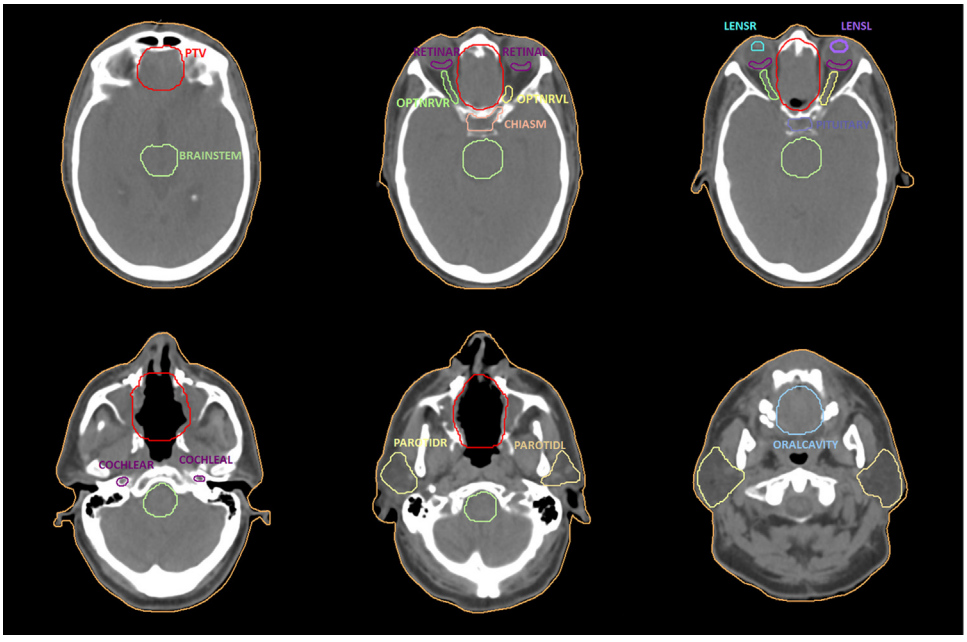

Fig. 1 – Nasal cavity structures. Nasal cavity case CT images slices containing all the structures considered for planning.

For the PTV, the score was calculated according to the following expression:

$$\text{Score}_{\text{PTV}} = \frac{D_{\text{TC,PTV}}}{D_{\text{P,PTV}}} \quad (2)$$

where $D_{\text{TC,PTV}}$ corresponds to the tolerance criteria for the PTV (in this case the dose in 98% of the PTV that should be at least 95% of the prescribed dose) and $D_{\text{P,PTV}}$ is the planned dose in the PTV. This is a target coverage criterion.

For the OARs, the score was set as:

$$\text{Score}_{\text{OAR}} = \frac{D_{\text{P,OAR}}}{D_{\text{TC,OAR}}} \quad (3)$$

where $D_{\text{P,OAR}}$ is the OAR planned dose and $D_{\text{TC,OAR}}$ is the tolerance dose for each OAR. In this clinical example, the score of each structure was based on the tolerances commonly used in our clinical practice corresponding to ICRU Report 83[24] planning aims. For some pathologies, there are broad consensus guidelines (e.g. RTOG0615 for nasopharyngeal cancer). Yet, seldom will a radiation oncologist be able to give the planner more than accepted tolerance doses for OARs either expressed as maximum doses or mean doses in a volume, considering more or less subjective values for the probability of complications in a tissue while selecting treatment plans. The plan is considered acceptable for treatment when these criteria are met. In this study the function score adopted compares the ratio between the prescription and the planned dose. But this function serves just as an example. SPIDERplan admits any type of score function as long as the unity value separates admissible from inadmissible planning aims. These definitions are not static and can be customized in any moment according to the clinician criteria and to the case specificity.

3.3. *SPIDERplan clinical validation*

As SPIDERplan was developed to reflect the radiation oncologist criteria when he/she is approving a plan, a clinical validation of the tool was performed prior to its application. First, all plans were assessed and ranked by the radiation oncologist using traditional tools: the DVHs, the dose statistics and the dose distribution visualization, in a completely independent way from SPIDERplan. To complete clinical plan evaluation, the radiation oncologist classified the plans as 'Good', 'Admissible with minor deviations' or 'Not admissible'.

To calibrate SPIDERplan to the radiation oncologist criteria and preferences, a matrix, named here weight sensitivity matrix, was determined. This matrix was calculated by varying the weights of all groups and considering all possible group weights combinations. The weight of the group representing the OAR was varied from 0% to 100% in steps of 10%. For the PTV group the weight varied from 10% to 100% also in steps of 10%. The set of group weights that better fitted the radiation oncologist evaluation was selected in SPIDERplan processing.

4. Results

4.1. *SPIDERplan outputs*

The proposed plan evaluation tool functionality and results will be illustrated through the chosen nasal cavity clinical case. SPIDERplan processing phase used the groups and structures defined in Table 1, and the group clinical weights defined by the radiation oncologist.

The subsequent assessment phase for SPIDERplan generated different radar plots that can be analyzed by the planner or the radiation oncologist. The SPD, GPD and SGD are shown in Figs. 2 and 3.

From the SPD the best overall plan was the iPlan OAR High (displayed polygon closer to the plot centre). By contrary, Oncentra and the iPlan OAR Low plans were of lower quality. The diagram is complemented by the global score that confirms that the plan iPlan OAR High, with a global score of 0.940, was the best dose distribution while the iPlan OAR Low plan, with the score of 1.040, was the worst plan. GPD is the condensed diagram showing the results for the groups. For the nasal cavity tumour case the plan iPlan OAR High was the only plan to achieve a global score equal or less than one for all groups. iPlan OAR Medium and iPlan OAR Low obtained a poor result for the Optics group and Oncentra for the PTV and the Optics groups. As the global score is derived using the same methodology in all diagrams, both radar plots may be used for plan selection.

A more detailed analysis of plan quality can be done evaluating the score of each structure in a given group (Fig. 3). For structures belonging to a group with just one element, like the PTV group, this can be done directly in the Structures Plan Diagram. For the PTV, the lowest score was achieved by the iPlan OAR Low plan with a value of 0.959, followed by the iPlan OAR High, Medium and the Oncentra plans with scoring values of 0.969, 0.997 and 1.009, respectively. For larger groups, a more comprehensive analysis can be performed by visualizing the SGD (Fig. 3). For structures belonging to the Optics group, iPlan OAR High was the only plan that accomplished all the clinical criteria (the red polygon is included in the inner circle). By contrary iPlan OAR Low plan was unable to achieve any of the clinical constraints for this group (the green polygon is external to the unitary circle), presenting the worst score values for the retinas and the lens. For the optic nerves and the chiasm, the worst results were obtained for the Oncentra plan (blue line). In general, for the Optics Group diagram, the best plan scoring was achieved by iPlan OAR High followed by iPlan OAR Medium, Oncentra and iPlan OAR Low with group score values of 0.972, 1.003, 1.069 and 1.205, respectively. For the Other group, all plan optimizations met the respective clinical criteria defined for the OARs in this group. The absolute value of these partial group scores can just be used for relative comparisons within each group.

4.2. *SPIDERplan clinical validation*

Prior to SPIDERplan configuration, the radiation oncologist was asked to evaluate all iPlan and Oncentra plans using

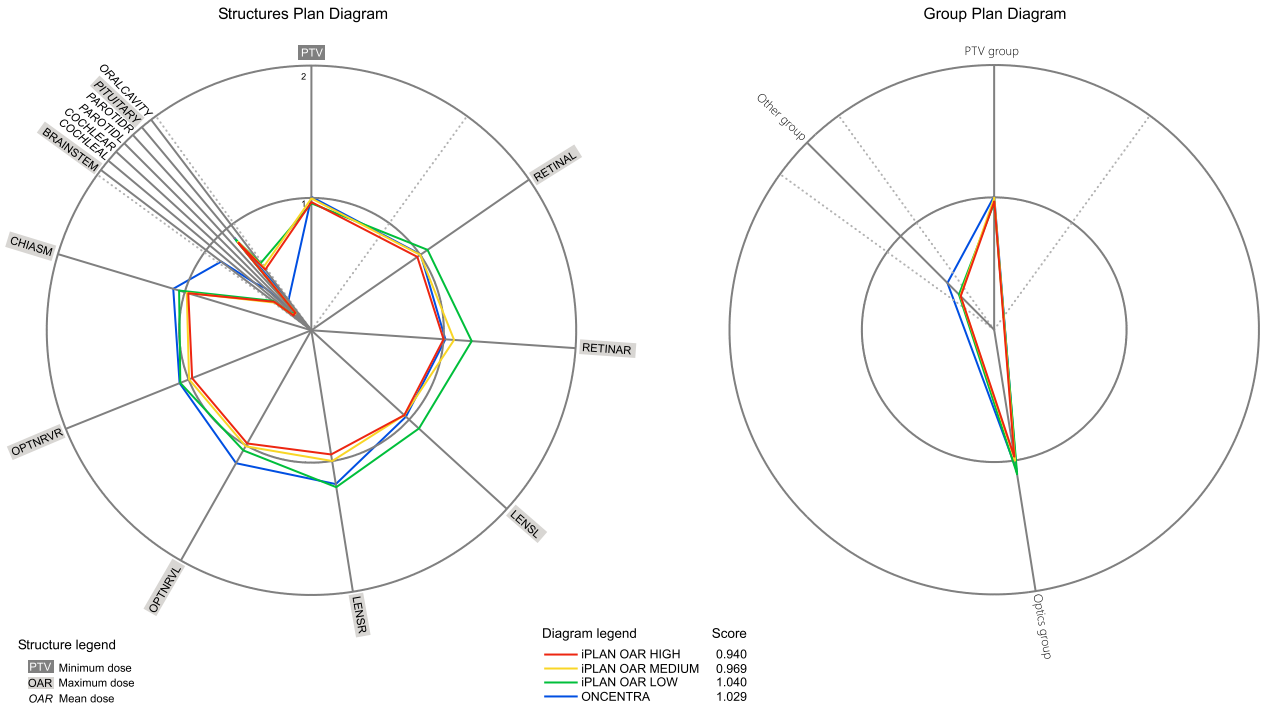

Fig. 2 – Structures Plan Diagram and Group Plan Diagram. SPIDERplan Structures Plan Diagram and Group Plan Diagram obtained for a nasal cavity tumour case. The solid rays of the diagram correspond to a structure and the dashed rays limit each group.

traditional tools (DVHs, planar dose distributions, etc.). The results are shown in Table 2. All plans were considered acceptable for treatment. iPlan OAR High was the plan that achieved the best rank followed by the iPlan OAR Medium, Oncentra and iPlan OAR Low plans. All plans, with the exception of the iPlan OAR High plan, were classified as 'Admissible with minor deviations'. iPlan OAR High plan was qualitatively evaluated as 'Good'.

Fig. 3 – Structures Group Diagram. SPIDERplan Structures Group Diagram generated for the Optics group and for the Other group, respectively.

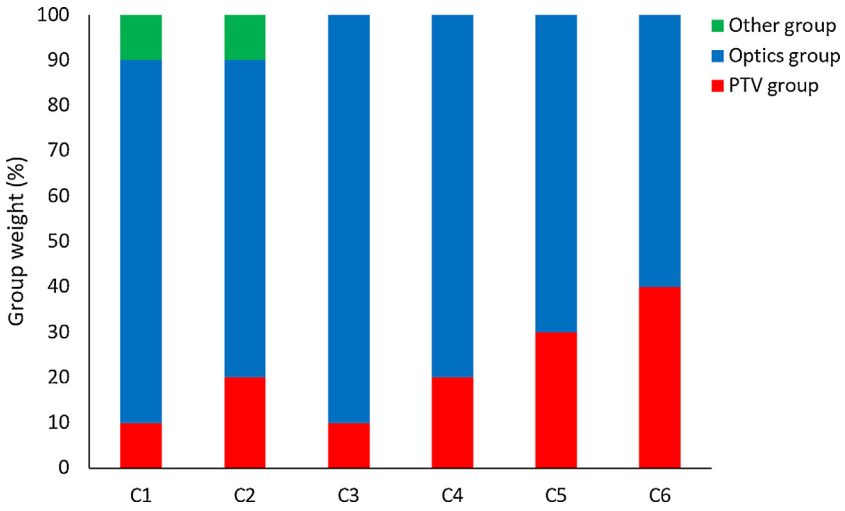

Fig. 4 – Group weight sensitivity cluster. Cluster of combinations of group weight that produce the same plan ranking as the radiation oncologist.

Table 2 – Clinical evaluation of the optimized IMRT plans in iPlan and Oncentra.

Name	Clinical plan assessment	
	Rank	Qualitative classification
iPlan OAR High	1	Good
iPlan OAR Medium	2	Admissible with minor deviations
Oncentra	3	Admissible with minor deviations
iPlan OAR Low	4	Admissible with minor deviations

To test the sensitivity of the weights needed for SPIDERplan configuration, the weight sensitivity matrix was calculated. From all combinations of group weights, the cluster with those weight combinations that maintained the plan ranking of the radiation oncologist (Table 2) has been selected. Fig. 4 shows the six combinations of group weights of this cluster clearly illustrating that while the weights of the Optics group ranged from 60% to 90%, the PTV group weights ranged from 10% to 40% and the Other group weights ranged from 0% to 10%, plan ranking remaining unchanged. In all six group weights combinations, a common trend was verified: the Optics group presented a higher weight than the PTV group and the Other group. Furthermore, the weight assigned to each group is not critical as there is a relatively large range where the quality of the plans is sorted by SPIDERplan and the radiation oncologist in the same way.

Using this analysis a robust weight assignment could be done in SPIDERplan processing for the nasal cavity. The mean values of the weight group ranges of the weight sensitivity matrix were taken as: 75% for the Optics group, 20% for the PTV group and for 5% the Other group.

5. Discussion

The ideal tool to support treatment plan evaluation would be able to provide an objective measure identifying the best treatment by quantitatively assessing the quality of the dose distribution and consistently compare different plans.[25] During the last two decades several proposals have been presented. Nevertheless, due to their complexity or conceptual limitations, no solution has been systematically adopted by the radiation oncology community.

SPIDERplan was designed to be incorporated in a TPS as one of the evaluation tools aiming to complement existing ones and not to replace traditional plan evaluation methods, like dose distribution visual inspection or DVH analysis. Multicriterial optimization and Pareto front navigation are eligible applications of the proposed tool. In those environments, by definition, a multiplicity of plans are to be considered. Along with playing with a display tool for Pareto front navigation, as described by Craft et al.,[26] the physician could also have an immediate picture of the whole set of plan possibilities in just one graph. With the benefit of having a complementary information on the relative value of each plan according to his/her own criteria.

The novelty of the proposed tool is not in the use of radar plots. There are many examples in the literature of their usage.[27,28] The novelty of SPIDERplan is the way the radar plot is built. By incorporating the clinical criteria defined in dose prescription, SPIDERplan becomes a graphical representation of radiation oncologists' viewpoints leading to plan approval. With just one diagram, combined with a score index, the medical team would be able to take decisions consistently when comparing different plans. It is a simple idea using common graphics to handle a difficult problem. SPIDERplan intuitive design allows a much faster decision in selecting the best plan taking into account all structures. When the polygon runs outside the inner circle (of radius one), dose objectives or constraints are surpassed and plan may be rejected. Otherwise, the dose distribution fulfils dose prescription and tolerances and the polygon with the smallest area indicates the best plan available.

Treatment plan quality assessment performed by SPIDERplan can be applied to all pathologies, dose calculation algorithms and delivery techniques. It incorporates the potential for customization for each radiation oncologist priorities and criteria needed for plan approval. This is accomplished by assigning in the processing phase a pre-defined relative

weight to groups and structures that can be adjusted according to the case complexity or clinical demands. The score function determined for each structure is also configurable. Different scoring indexes based on traditional DVH information, or any other relevant physical or biological quantities like EUD, TCP, NTCP, etc.[29] may be set up. This flexibility confers to SPIDERplan the possibility to be easily adapted to new situations that are recurrent in the clinical routine. For instance, some special clinical situation where a given OAR should be given a stronger relevance or the inclusion of a structure in the optimization process that is not usually considered. For situations where mixture of different types of planning goals are specified for each structure, the user can use composite scores[16] or more than one radius per structure in the SPIDERplan radar plot. For the hot spots situations, a score including unspecified normal tissue (body minus PTVs) dose restriction may be included. Also, some penalties to structure scores can be introduced in order to point unacceptable deviations that would lead to rejected plans.

The processing phase can be constructed on a class-solution basis, like for instance some "wish-lists" that have been proposed for optimization steering.[30] All these tool refinements must be conducted in close collaboration with radiation oncologists. Some time and effort needs to be invested in the pre-processing phase to clinically validate SPIDERplan for each tumour site. To adjust SPIDERplan plan assessment with the radiation oncologist evaluation is an essential step to enhance the confidence and creditability in this new tool. The proposed weight sensitivity matrix method expresses the clinical preferences for plan assessment and gives a picture of the sensitivity of the clinical weights that should be used in the configuration of SPIDERplan. This initial effort will be compensated by a much faster plan evaluation and treatment selection of similar clinical cases.

SPIDERplan potential to compare and rank treatment plans was demonstrated in the chosen nasal cavity tumour case. After the clinical validation, the graphic information included in the Structures Plan Diagram, the Group Plan Diagram and the Structures Group Diagram enabled a fast and intuitive assessment of the quality of the dose distribution in the PTV and all OARs. To complement the diagrams evaluation, the plan global score provided a quantitative measure of plan quality. This measure was embedded in the SPIDERplan construction, including both the score achieved by each structure and its relative importance according to the local or individual clinical reasoning. The new tool is independent from the TPS and the dose calculation algorithm. In a simple and systematic way it is possible to compare plans from different sources and consistently infer about their relative quality. The only requirement is that the dose prescription, either in the form of dose objectives or constraints, is the same. The number of structures in the presented clinical example was restricted to 15 (Table 1) but this number has no limitation. Although the Structures Plan Diagram may appear too confusing for more complex cases, the Structures Group Diagrams may then be preferable and simpler to analyze providing the same global result. Moreover, the global plan score will complement the information provided by the radar plots quantifying the quality of the best plan by incorporating the dose prescription and tolerances defined for all target volumes and OARs.

6. Conclusions

A graphical method for comparison and assessment of the quality of radiation therapy plans was developed. A clinical planning case of the nasal cavity was used to illustrate its operationality, functionalities and potential. Due to its simplicity and flexibility, SPIDERplan can be applied to all types of radiotherapy delivery techniques. The graphical information generated by the Structures Plan, the Group Plan and the Structures Group Diagrams complemented by the global plan score enables a fast and intuitive plan quality assessment incorporating all clinical priorities and criteria established for treatment plan approval.

Following the local clinical practice, the complete list of clinical planning aims needs to be translated into SPIDERplan inputs. These may be established in terms of dose prescription, PTV coverage and conformity, dose tolerance to OARs, dose–volume conditions, etc. The customization process must be clinically validated by comparing the results of the SPIDERplan assessment with the radiation oncologist evaluation. This tuning phase will confirm consistency with the processing data of SPIDERplan.

It was demonstrated that SPIDERplan can be used as a useful tool for supporting clinical plan approval with full customization potential to any local clinical practice. After the clinician realizes that his/her priorities and goals are fully reflected in the graphics and scores, SPIDERplan can easily be adopted with a very steep learning curve.

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