Automatic treatment planning implementation using a database of previously treated patients

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Purpose/Objectives

- Using a database of prior patient dose and shape relationships allows for the prediction of dose on future patients.
- Automatic planning improves the speed of treatment planning by providing a good initial plan for the dosimetrist to start from
- Database driven solutions improve quality by predicting the lowest known achievable critical structure dose from prior patients
- Safety is improved by showing suggesting solutions that are more realistic
- Toxicity and other planning data can be recorded to improve plan selection

Materials/Methods

- Database consists of 53 patients from 3 institutions
- Dose and structure data is available for 46 patients from 2 institutions.
- Prior planning information is stored in an SQL relational database.
- Automated scripts written in Python and connected to a commercial treatment planning system
- The database schema is stores dose, structure, and toxicity information

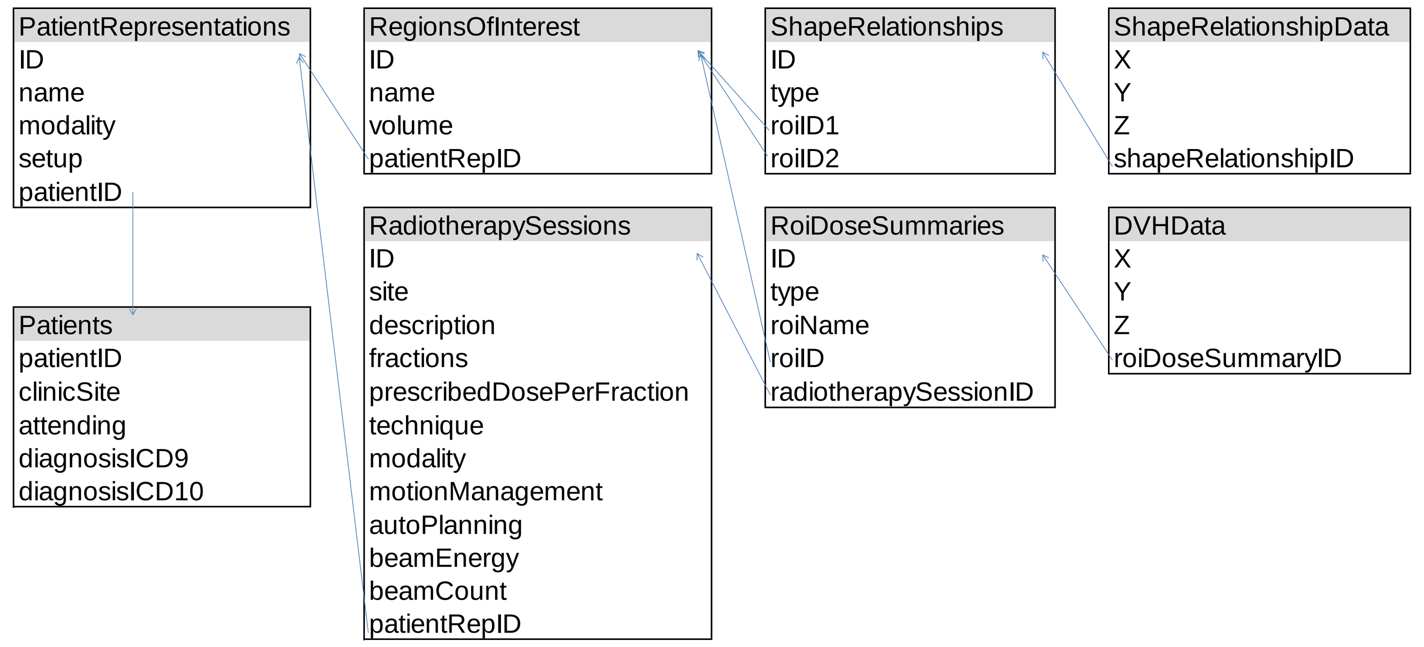

Figure 1: Database schema. Database contains planning, dose and structure data for each patient. Raw dose and shape relationship points are stored in the database for maximum flexibility in lookup.

- For consistency, a tool (Figure 2) is used to map names to a standardized scheme.
- Common alternative structure names are automatically mapped to standard names. Uncommon names can be renamed manually.
- Structures are grouped into PTV, OAR and None
  - PTVs and OARs are added to database
  - Structures marked as None are ignored
- The planning tool allows for rapid plan generation (Figure 2 inset)
  - Adds ring structures and combines common OARs
  - Places isocenter and pre-defined beam sets
  - Sets a prescription based upon the selected plan type
  - Selects a dose grid that covers all relevant structures
- Software verifies required structures are present
  - Missing or misnamed structures are identified
  - Duplicate structures in the mapping process are identified
  - User is prompted before the planning tool is started
- Overlap Volume Histograms (Figure 3) are computed for each PTV-OAR combination

Materials/Methods (cont.)

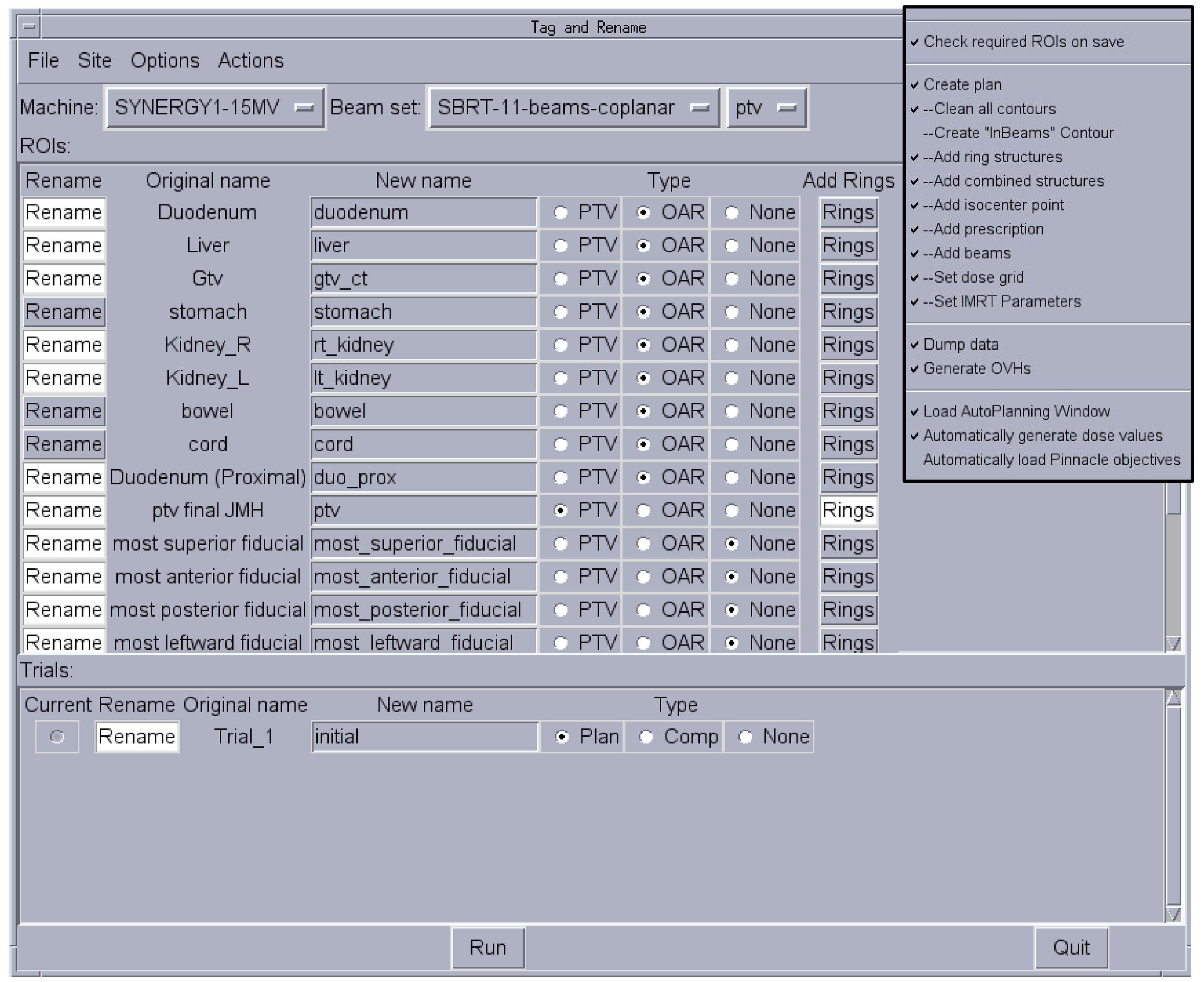

Figure 2: Renaming and planning tool. ROIs are named to a common scheme and type is selected. Plans can be generated by selecting machine and beam arrangement. (inset) Menu to select planning options

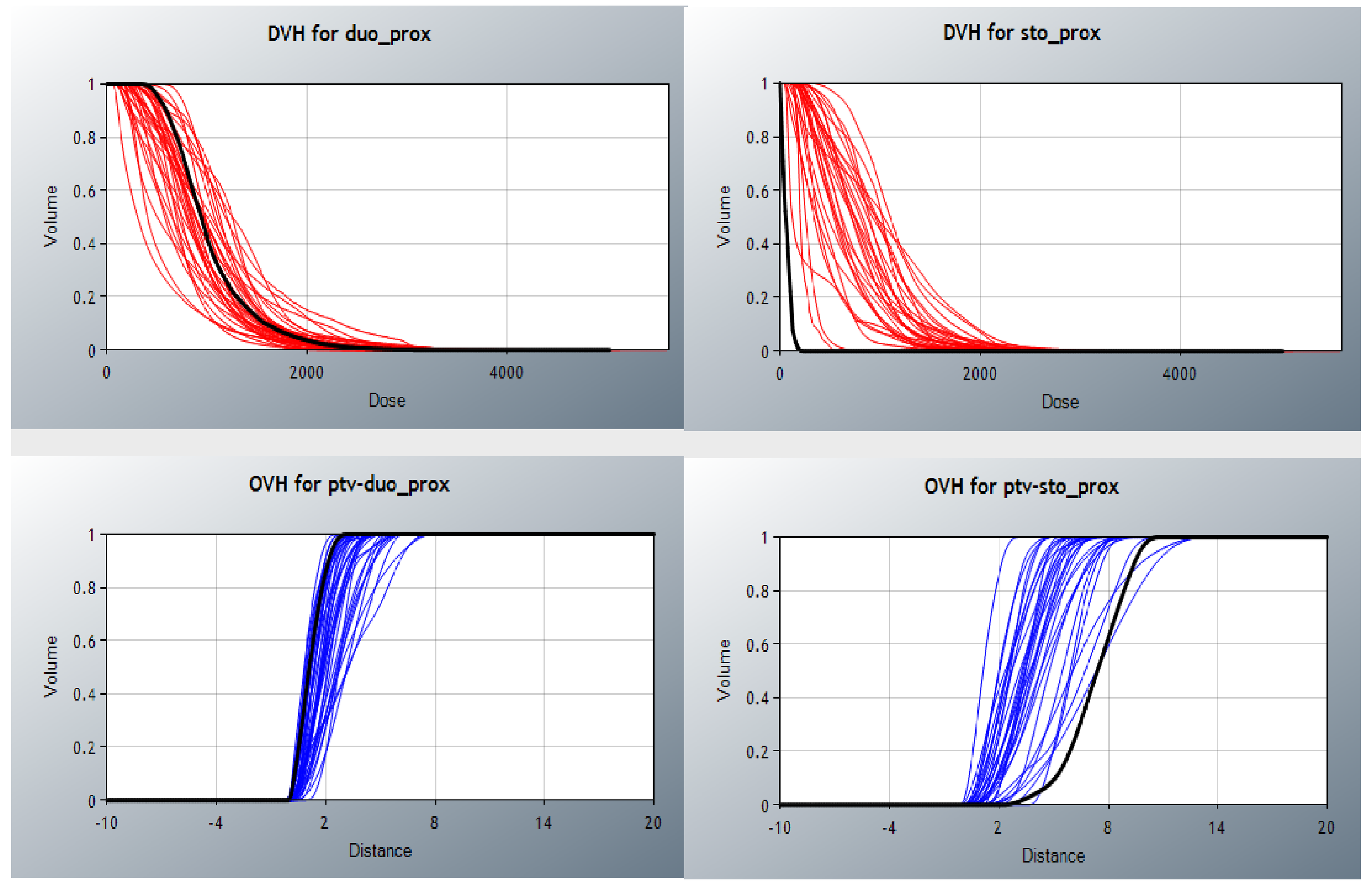

Figure 3: Overlap Volume Histograms represent relative volume of overlap of the OAR with the target as a function of expansion distance of the target. They can be read as Y% of the OAR is within X cm of the target. All patients with OVH curves left of the black line are harder to plan. The black DVH represents the same plan.

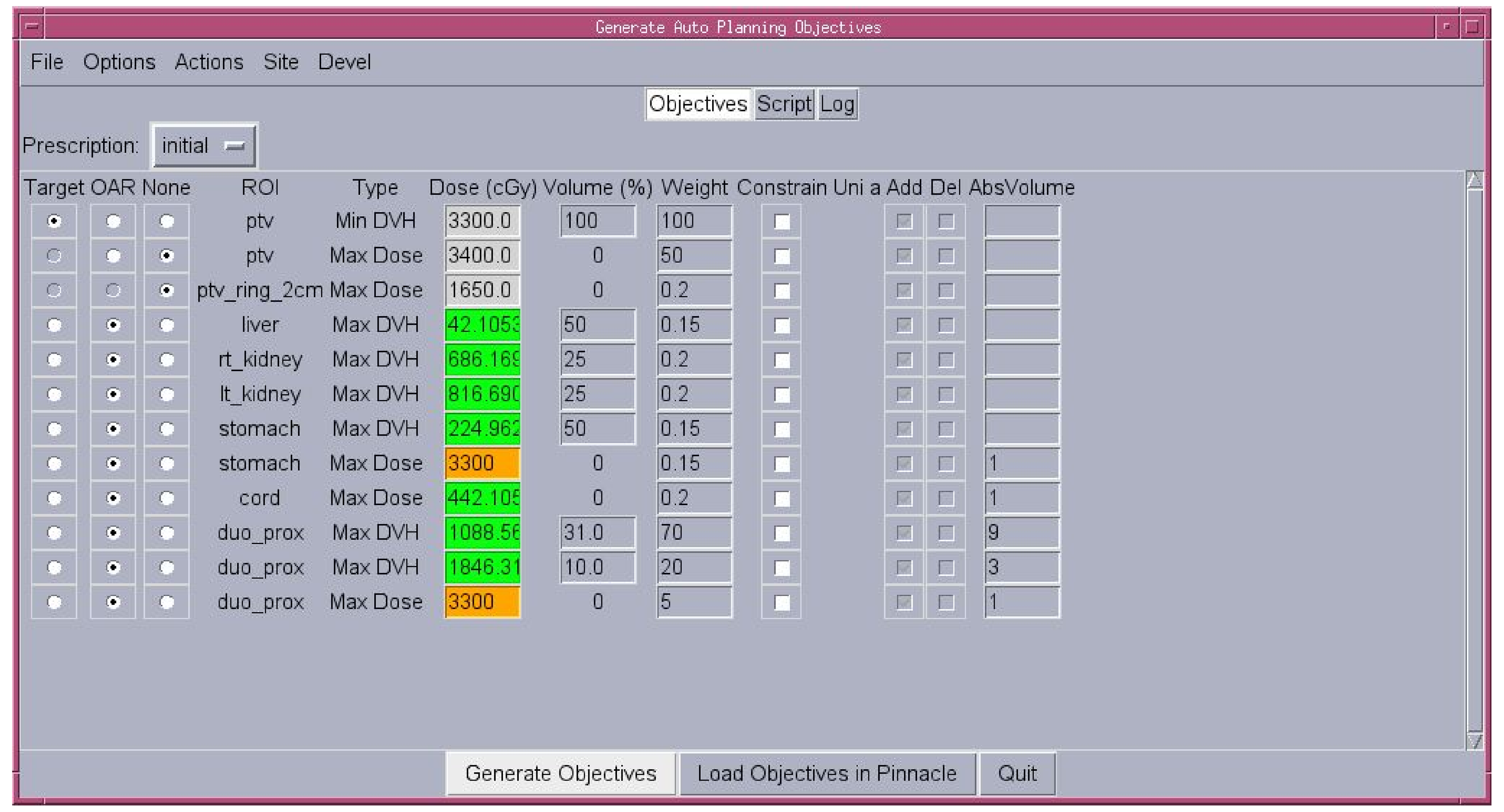

Figure 4: Auto planning objective lookup. Dose points are queried from database. Successful lookups are colored in green, unsuccessful lookups in orange. Values can be manually adjusted especially in the case of unsuccessful lookups.

- Automatic planning tool (Figure 4) queries optimization objectives from the database using calculated OVHs
- The interface allows for selection from a predefined set of prescriptions
- The query selects from the patients in the database those which have achieved a target dose greater or equal to the prescription target dose.
- For each structure, the patients which have the same or closer shape relationship between the target and structure is selected. The lowest achievable dose from this group is returned by the query
- Unsuccessful queries are from more difficult cases where there is no shape relationship in the database of equal or closer distance.

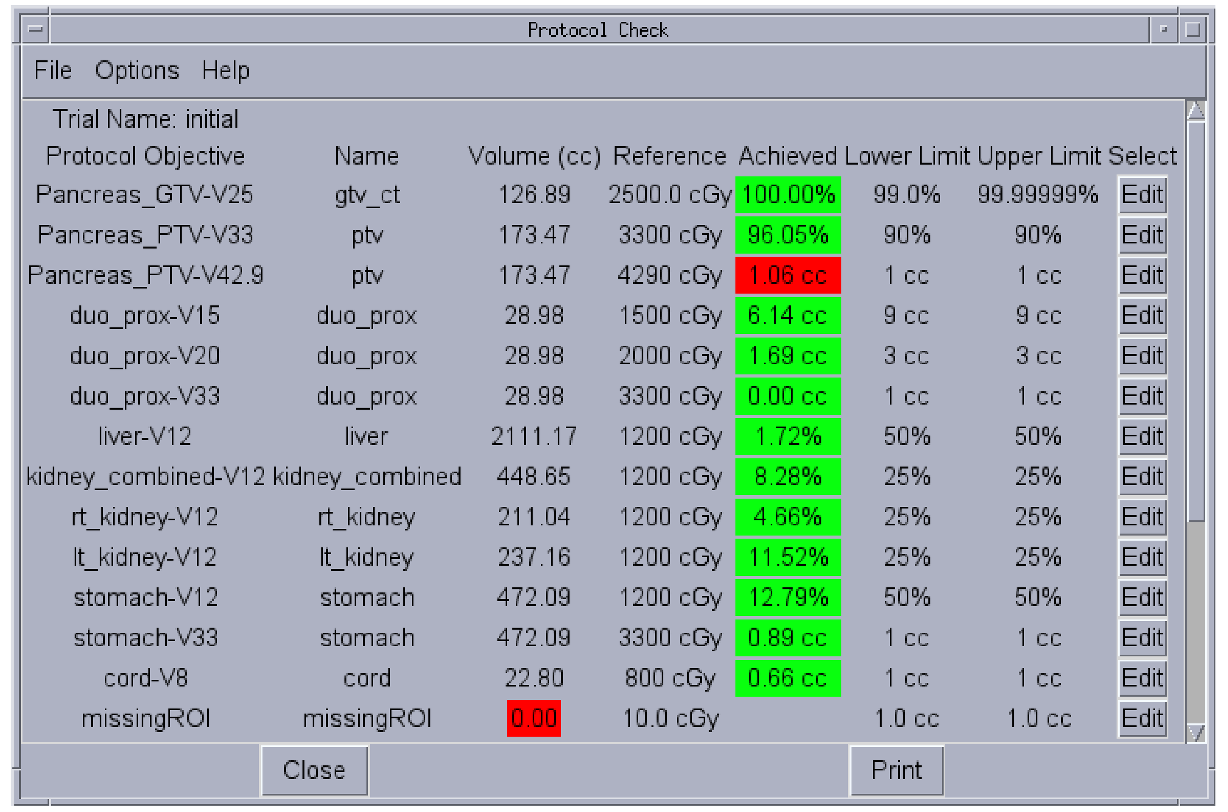

Figure 5: Protocol check interface. Color coded values indicate which objectives are achieved and which are not met. Volumes highlighted red indicate missing structures.

- Plan evaluation dashboard (Figure 5) is used to check protocol compliance
- Protocol objectives are defined in a comma separated values file and allow flexibility in defining protocol parameters including upper and lower limits on goals.
- Plans can be evaluated with a single click from the planning system and the resulting spreadsheet can be included in plan documentation

Results

- OVH calculation requires 122 +/- 36 seconds for a pancreas SBRT plan
- Objective query requires approximately 4 seconds
- A typical plan optimization requires approximately 2.5 minutes.
- With just one optimization iteration saved, total planning time is reduced.
- Safety is improved by reducing plans which exceed protocol limits (Figure 6)
- Quality is improved by trending to lower dose to critical structures (Figure 7)

	Standard Planning			Automatic Planning		
Site	Count	Exceeds	Exceeds%	Count	Exceeds	Exceeds%
Proximal Duodenum - D1cc	18	1	6%	17	0	0%
Proximal Duodenum - D3cc	17	3	18%	16	0	0%
Proximal Duodenum - D9cc	17	6	35%	16	1	6%
Proximal Stomach - D1cc	20	0	0%	17	0	0%
Proximal Stomach - D3cc	20	1	5%	17	0	0%
Proximal Stomach - D9cc	20	1	5%	16	0	0%
Cord-D1cc	22	3	14%	20	1	5%

Figure 6: Automatic planning reduces cases which exceed protocol specifications

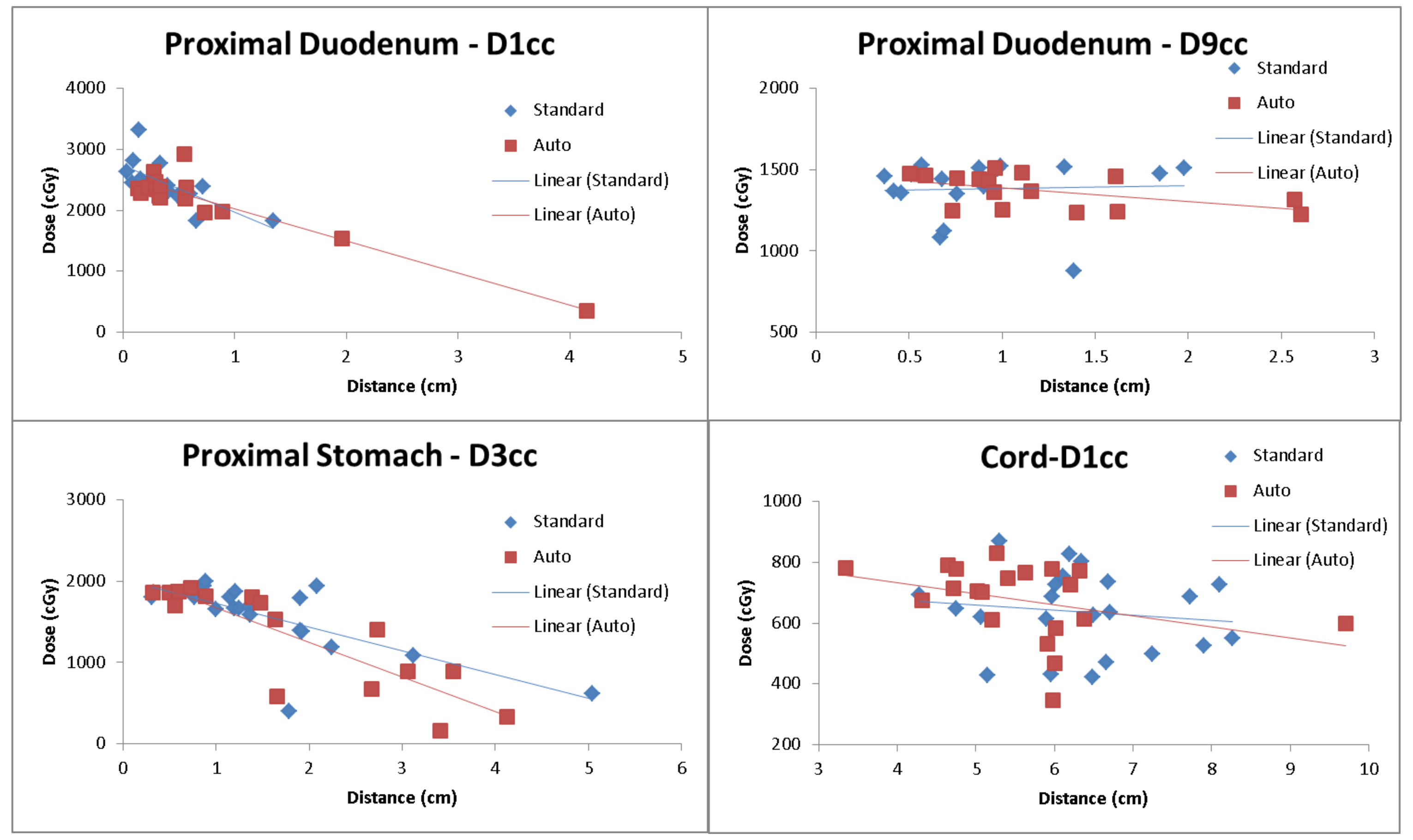

Figure 7: Automatic plans trend towards lower dose as distance from critical structures increases

Conclusions

- The automatic planning tool is currently being used for all pancreas SBRT patients at Johns Hopkins.
- The automatic planning tool allows for faster planning when compared to manual planning with improved quality.
- Using an automatic planning tool allows for less experienced planners to generate high quality plans based upon prior patient data.
- Plan evaluation dashboard allows for rapid evaluation of plans.
- Plans can be further improved by adding more plans to the database.

Acknowledgements

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