On the selection of gamma criteria (by evaluation of clinical results)

Scott Crowe, Bess Sutherland, Rachael Wilks, Venkata Seshadri, Steve Sylvander and Tanya Kairn

Introduction

- Many centres use gamma evaluation for patient specific pre-treatment quality assurance
- Why do centres use 3%/3mm –
  - that is what Low / other groups used
  - it seems 'reasonable', compared to resolution, delivery confidence
- How do centres determine action level –
  - they use the 90% recommended by AAPM TG119 (for radiochromic film), or some other value from the literature / vendor
  - or, they choose so as to give a reasonable number of plans passing/failing (or to identify outliers with pass rates > 1 standard deviation from mean, etc.)
  - or, they have independently evaluated confidence limits on measurement accuracy for their system or otherwise tested sensitivity to introduced errors
- Literature says tighten up!

Method

- Collected QA data
  - for 1265 radiotherapy beams
  - from 7 treatment centres (RBWH, PAH, GCCQx5)
  - from 4 planning systems (Eclipse, iPlan, Pinnacle, Hi-Art)
  - using 3 treatment modalities (IMRT / VMAT / HT)
  - using 3 QA systems (Epiqa, MapCheck, ArcCheck)
- Treatments grouped in 8 sets
- Gamma agreement indices were calculated at %/1mm, 2%/2mm, 2%/3mm, 3%/2mm, 3%/3mm and 5%/3mm
  - global normalisation
  - 10% lower dose threshold
- These centres were doing gamma evaluation on QA measurements for all modulated treatment techniques (hundreds a year!)

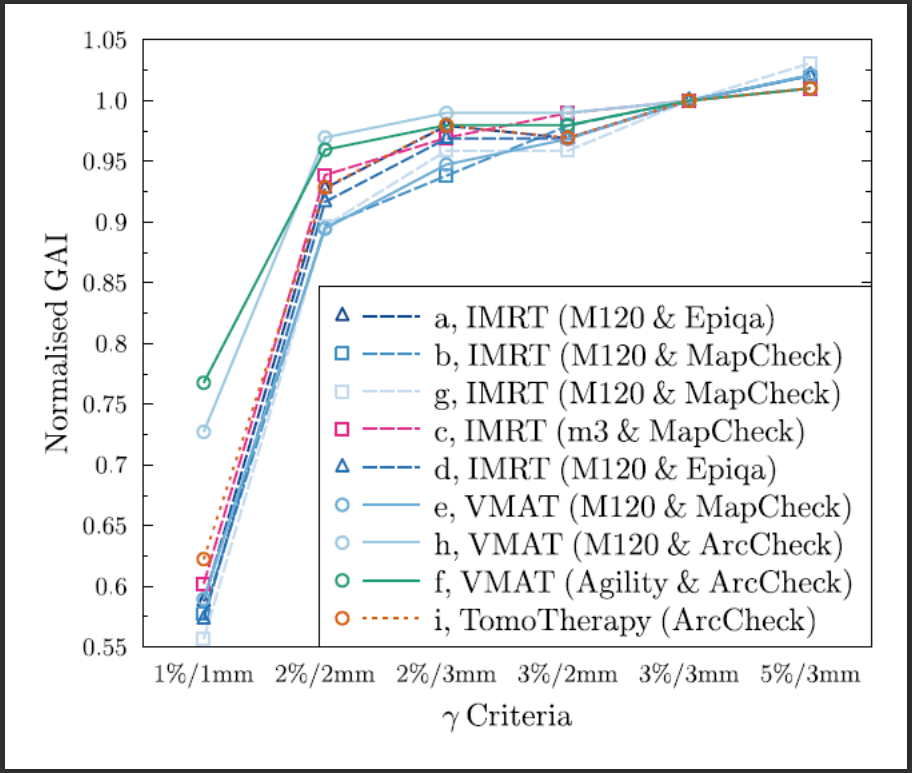
Available data

Set	Beams	TPS	Linac	Dosimeter	Software
a	IMRT (402)	Eclipse v11	Varian	aS1000	Epiqa
b	IMRT (128)	Eclipse v9	Varian	MapCheck2	MapCheck
c	IMRT (150)	iPlan v4.5	Varian & m3	MapCheck2	MapCheck
d	VMAT (148)	Eclipse v11	Varian	aS1000	Epiqa
e	VMAT (85)	Eclipse v9	Varian	MapCheck2	Map
f	VMAT (109)	Pinnacle v9.8	Elekta	ArcCheck	SNC Patient
g	IMRT (107)	Eclipse v13.5	Varian	MapCheck2	SNC Patient
h	VMAT (50)	Eclipse v13.5	Varian	ArcCheck	SNC Patient
i	HT (86)	Hi-Art II	Tomo	ArcCheck	SNC Patient

Method

- Pass rates for 1%/1mm, 2%/2mm, 2%/3mm, 3%/2mm, 5%/3mm plotted against 3%/3mm
- Linear regression used to evaluate relationship between pass rates
- This could, for example, suggest what a 2%/2mm gamma evaluation pass rate would be for a 3%/3mm pass rate of 94%
  - That is, you could determine an action level that would result in a similar number / cohort of beams failing QA

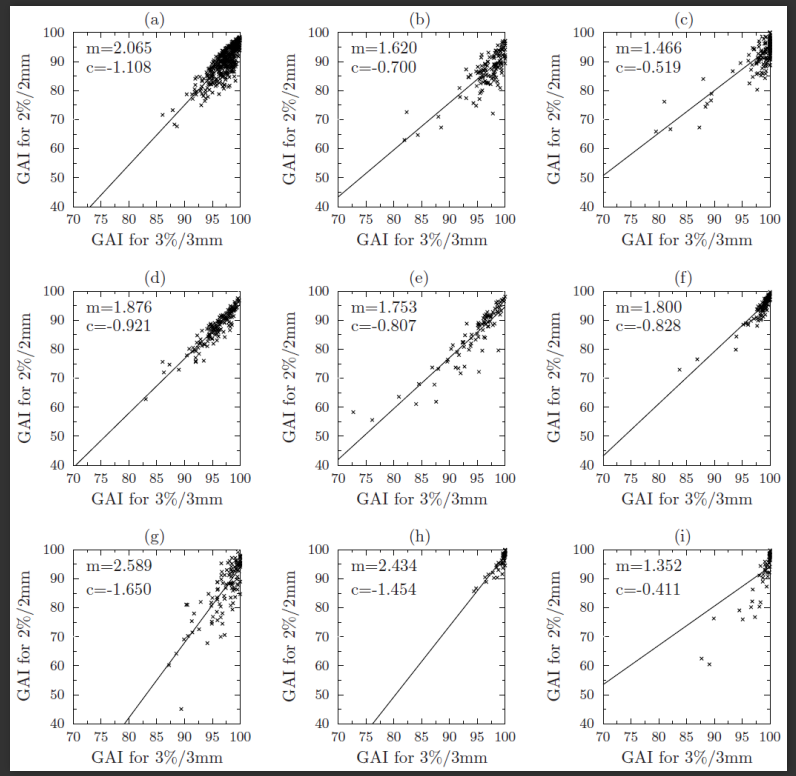
Results



- Mean gamma pass rate (GAI) for each gamma criteria pair, normalised to 3%/3mm baseline.
- MapCheck2 – square, ArcCheck – circle, Epiqa – triangle
- M120 – blue, m3 – pink, Agility – green, Tomo – orange
- VMAT – solid, IMRT – dashed, HT - dotted

Results

- Pass rates for 3%/3mm vs. 2%/2mm shown
- Fit found between 2%/2mm, 2%/3mm, and 3%/2mm; and 3%/3mm
- Suggesting that those criteria, assuming an appropriate action level was chosen, would result in similar cohort of plans failing QA
- Relationship fell apart at 5%/3mm (information lost at 100% gamma pass)
- Relationship fell apart at 1%/1mm (data density of detectors)



Results

Set	1%/1mm	2%/2mm	2%/3mm	3%/2mm	5%/3mm
a	46%	75%	82%	85%	96%
b	44%	76%	87%	80%	95%
c	45%	80%	89%	83%	92%
d	42%	77%	85%	84%	95%
e	47%	77%	87%	82%	94%
f	57%	79%	86%	85%	95%
g	36%	68%	81%	79%	99%
h	22%	74%	83%	84%	97%
i	51%	85%	86%	87%	93%
All	**43%**	**76%**	**85%**	**83%**	**95%**

Pass rates that are clinically equivalent to 90% pass rate (or action level) at 3%/3mm, for other criteria

Conclusions

- Centres here using 3%/3mm could adopt 2%/2mm, 2%/3mm or 3%/2mm (with a new action level), and observe the same plans fail
- Obvious question – why tighten up if the same plans will fail?
  - more data: wider range of values, less 'clipping' at 100% pass rate
- Using 1%/1mm with these systems wouldn't see the same plans failing (because 1%/1mm is too strict for these systems)
- For most systems examined a 1mm change in DTA has a larger effect than a 1% change in ΔD
- Device resolution visible in difference between pass rates with criteria
- This data could be used to determine clinical equivalence of pass rates reported in the literature compared to local values
  - e.g. centre A finds mean pass rates of 93% for H&N plans at 3%/3mm, centre B finds mean pass rates of 86% at 2%/2mm – are those results similar?