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FULL PAPER

Prostate cancer measurements on serial MRI during active surveillance: it's time to be PRECISE

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Objective: The PRECISE criteria for reporting multiparametric MRI in patients on active surveillance (AS) for prostate cancer (PCa) score the likelihood of clinically significant change over time using a 1–5 scale, where 4 or 5 indicates radiological progression. According to the PRECISE recommendations, the index lesion size can be reported using different definitions of volume (planimetry or ellipsoid formula) or by measuring one or two diameters. We compared different measurements using planimetry as the reference standard and stratified changes according to the PRECISE scores.
Methods: We retrospectively analysed 196 patients on AS with PCa confirmed by targeted biopsy who had two MR scans (baseline and follow-up). Lesions were measured on T_2 weighted imaging (T_2WI) according to all definitions. A PRECISE score was assessed for each patient.
Results: The ellipsoid formula exhibited the highest correlation with planimetry at baseline (ρ = 0.97) and follow-up (ρ = 0.98) imaging, compared to the biaxial measurement and single maximum diameter. There was a significant difference ($p < 0.001$) in the yearly percentage volume change between radiological regression/stability (PRECISE 2–3) and progression (PRECISE 4–5) for planimetry (39.64%) and for the ellipsoid formula (46.78%).
Conclusion: The ellipsoid formula could be used to monitor tumour growth during AS. Evidence of a significant yearly percentage volume change between radiological regression/stability (PRECISE 2-3) and progression (PRECISE 4-5) has been also observed.
Advances in knowledge: The ellipsoid formula is a reasonable surrogate for planimetry in capturing tumour volume changes on T_2WI in patients on imaging-led AS. This is also associated with radiological changes using the PRECISE recommendations.

INTRODUCTION

Tumour volume is a well-known prognostic factor in prostate cancer (PCa).[1]

Multiparametric magnetic resonance imaging (mpMRI) is the modality of choice for the detection and localisation of PCa and several studies have investigated the accuracy of different measurements of PCa on mpMRI using whole-mount pathology as the reference standard.[2–11]

At present, there is scant literature on the accuracy of mpMRI in determining PCa volume in patients on active surveillance (AS).[12]

In addition, there is still no consensus on the most accurate measurement for monitoring lesion size on serial mpMRI. This was clearly outlined during the Prostate Cancer Radiological Estimation of Change in Sequential Evaluation (PRECISE) consensus meeting in 2016,[13] when the PRECISE scoring system was created. The PRECISE score assesses the likelihood of radiological progression on follow up scans using an ordinal 1-to-5

Table 1. Assessment of likelihood of radiological progression on magnetic resonance imaging in patients on active surveillance (PRECISE score)

PRECISE score	Assessment of likelihood of radiological progression
1	Resolution of previous features suspicious on MRI
2	Reduction in volume and/or conspicuity of features suspicious for prostate cancer
3	Stable MRI appearance: no new focal/diffuse lesions
4	Increase in size and/or conspicuity of features suspicious for prostate cancer
5	Definite radiologic stage progression (ECE, SV involvement, LN involvement, metastasis)

ECE, extracapsular extension; LN, lymph node; MRI, Magnetic Resonance Imaging; PRECISE, Prostate Cancer Radiological Estimation of Change in Sequential Evaluation;SV, seminal vesicle.
Reprinted from Moore CM, Giganti F, Albertsen P, et al. Reporting Magnetic Resonance Imaging in Men on Active Surveillance for Prostate Cancer: The PRECISE Recommendations - A Report of a European School of Oncology Task Force. Eur Urol. 2017;71(4):648-655, with permission from Elsevier.

scale, where a score of 1 or 2 denotes radiological regression, a score of 3 indicates radiological stability and a score of 4 or 5 implies radiological progression (Table 1).

According to the PRECISE recommendations, for patients with a visible lesion, the key metric is the size of the index lesion on the baseline mpMRI and at each subsequent time point.

During the PRECISE consensus meeting, it was acknowledged that the index lesion size on mpMRI can be reported using different definitions of volume (by planimetry or derived from three diameters using the ellipsoid formula) or measuring only one or two diameters. The panellists acknowledged that so far there is insufficient evidence to determine which of these methods for measuring size is optimal for distinguishing between natural fluctuation in tumour volume or true disease progression. Some of the panellists believed that planimetry volume would be most accurate but others were concerned that this is too time consuming and it was concluded that data from the same cohort on the reproducibility of different size measurements of the index lesion would be of great value in exploring this further.

This is the reason why we conceived this study at our institution (University College London Hospital). The purpose is twofold, as we aimed: i) to compare the different measurements for PCa during AS using tumour volume by planimetry as the reference standard and ii) to compare change in lesion size according to the PRECISE recommendations.

METHODS AND MATERIALS

This study follows the Standards for Reporting of Diagnostic Accuracy (STARD) guidelines.

Our AS cohort was established in 2005 in a prospective manner.[14] This includes patients who have had a prostate mpMRI and a biopsy-confirmed low- to intermediate-risk PCa (*i.e.* ≤Gleason 3 + 4 and prostate-specific antigen [PSA] ≤20 ng ml^{-1}) as per National Institute for health and Care Excellence (NICE) guidelines,[15] and who have chosen AS as initial management.

In this retrospective study, patient records and MR images were reviewed as part of an audit routinely performed for the internal evaluation of the AS service at our institution (University College London Hospital), which is in line with the UK NICE guidelines.[15]

Primary outcome

The primary outcome was to determine the most accurate method to assess PCa size during AS, using tumour volume by planimetry as the reference standard.

Secondary outcome

The secondary outcome was to investigate the relationship between tumour growth rate on serial mpMRI and the PRECISE score.

Study population

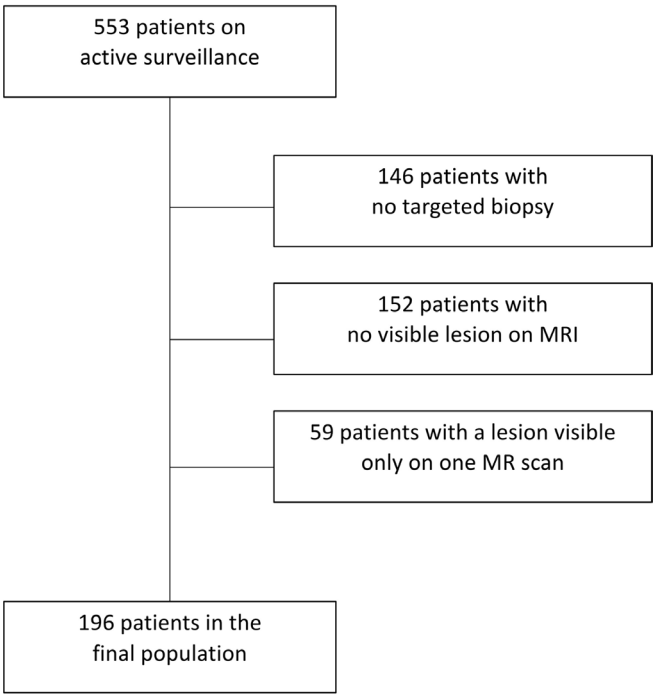
AS entry was defined as the date of initial diagnosis of PCa on biopsy. From our AS database, we applied the following inclusion criteria for this analysis: (i) a visible lesion scoring ≥3 according to Prostate Imaging-Reporting and Data System - PI-RADS- v. 2.1[16] guidelines on two mpMRI scans (baseline and follow-up, with the latter being the most recent if multiple scans had been performed over the years); ii) diagnosis of PCa confirmed by targeted biopsy of the lesion. The flowchart in Figure 1 shows patients' selection.

MpMRI analysis and PRECISE score assessment

All patients were scanned using a 1.5 T (Siemens Symphony or Avanto, Erlangen, Germany) or 3 T system (Philips Achieva, Best, The Netherlands) and a pelvic phased-array coil. The mpMRI protocol was in line with international guidelines[17,18] and included T_2 weighted imaging (T_2WI), diffusion-weighted (DWI) after 2006 (b values: 0, 100, 500, and 1000 s/mm^2, with a dedicated long b: 1400 s/mm^2 for 1.5 T or 2000 s/mm^2 for 3 T scanners), and dynamic contrast-enhanced (DCE) sequences.

For each patient, a dedicated radiologist (FG, with 7 years of experience in prostate mpMRI and reporting >1,800 prostate MRI scans per year) reviewed all mpMRI data sets in sequential order using a dedicated reporting tool (MIM® Symphony Dx v. 6.8.3, Cleveland, OH) that allows the collection of data from serial scans, including planimetric segmentation.[19]

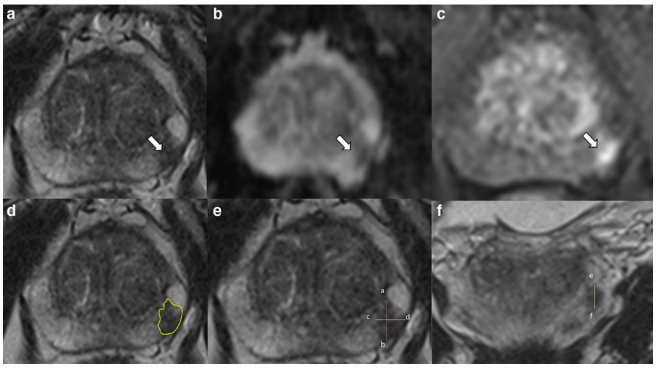
Figure 1. Flowchart shows study enrolment.



Prostate volume was calculated by planimetry on axial T_2WI. All mpMRI sequences were used to score the index lesion (defined as the largest lesion in case of multifocal disease) according to PI-RADS v. 2.1 guidelines.[16]

According to the PRECISE recommendations, the index lesion during AS can be measured using different techniques: i) by planimetry (*i.e.* contouring the lesion slice by slice), ii) using the ellipsoid formula [*i.e.* (anteroposterior X transverse X longitudinal diameter) * π/6], iii) by biaxial measurement of maximum diameters (*i.e.* estimated square area), and iv) by single maximum diameter.

Figure 2. 72-year-old male with biopsy-proven prostate cancer in the left peripheral zone at mid-base. The lesion (arrows) is clearly visible on T_2 weighted imaging (a), apparent diffusion coefficient map (b) and dynamic contrast-enhanced sequences (c). Lesion volume by planimetry is obtained contouring the lesion slice by slice on the axial image (d) while the volume using the ellipsoid formula is obtained using the three diameters from the axial (e) and coronal (f) acquisition according to the formula: (ab X cd X ef) * π/6.



As there are still no specific recommendations on the most accurate measurement of tumour size during AS,[13] we compared data exclusively from T_2WI according to all four different definitions (Figure 2).

In order not to introduce any recall bias, the PRECISE score for the likelihood of radiological progression was not assessed at this stage but it was recorded by the same radiologist on a separate spreadsheet 3 months later.

As per PRECISE recommendations, the radiologist was privy only to PSA, initial biopsy result and tumour location. The radiologist was not aware of the previous lesion measurements and each PRECISE score was the result of: i) visual evaluation (*i.e.* tumour conspicuity) and ii) volume changes by planimetry on the dominant sequence on follow-up scan as per PI-RADS v. 2.1 guidelines [*i.e.* the apparent diffusion coefficient (ADC) map for the peripheral zone and T_2WI for the transition zone]. If the measurement was not possible on the dominant sequence, this was made on the sequence that showed the lesion best, in accordance with PI-RADS v. 2.1 guidelines.[16]

Histology

The histology at entry into AS was either from untargeted transrectal, systematic transperineal template mapping or targeted biopsy. All patients included in this study had a visible lesion on mpMRI that had been confirmed at targeted biopsy (either at entry or during AS).

Statistical methods

Clinical and demographic data are reported using descriptive statistics.

Continuous variables are expressed by median and interquartile ranges [IQR] and categorical data by frequencies and percentages.

As the relationship among the different measurements is not linear, Spearman's rank correlation coefficients between tumour volume by planimetry (reference standard) and the other three measurements were estimated.

Bland–Altman plots were used to measure the agreement between tumour volume by planimetry and the ellipsoid formula.

Given the different time frames between the two mpMRI scans for each patient, tumour growth rate was adjusted for the intervening time interval in years (*i.e.* [baseline volume – follow-up volume/baseline volume] * 100, per year) and the relative percentage change was plotted on a waterfall plot according to the PRECISE score. This change was compared between the different groups using the Wilcoxon rank sum and Kruskal–Wallis tests.

All statistical analyses were performed in R (R Foundation for Statistical Computing, Vienna, Austria).

Table 2. Baseline characteristics of the entire cohort (n = 196)

Age (years)	63 (58–67)
PSA (ng/ml)	6.5 (4.9–9.06)
Prostate volume (cc)	43.1 (32.1–61.7)
PSA density (ng/ml/ml)	0.14 (0.1–0.19)
Gleason score at entry biopsy	
3 + 3	155 [79]
3 + 4	41 [21]
Imaging field strength	
1.5T	140 [71]
3T	56 [29]
Lesion location	
Peripheral zone	160 [82]
Transitional zone	36 [18]
PI-RADS	
3	62 [32]
4	124 [63]
5	10 [5]

PI-RADS, Prostate Imaging-Reporting and Data System; PSA, prostate specific antigen.
Data are medians and interquartile range (parentheses); percentages in brackets [%].

A p value of less than 0.05 was considered to indicate a significant difference.

RESULTS

The final cohort comprised 196 patients on AS, for a total of 392 scans acquired between December 2005 and November 2019.

The median interval between baseline and follow-up mpMRI was 36 months [IQR: 22.25–52.50]. Overall, 274/392 (70%) scans were conducted on a 1.5 T and 118/392 (30%) on a 3 T scanner.

Table 2 shows baseline characteristics of the entire population. 24 out of 196 (12%) patients were classified as PRECISE 2, 41/196 (21%) as PRECISE 3, 116/196 (59%) as PRECISE 4 and 15/196 (8%) as PRECISE 5.

Primary outcome

Table 3 lists the Spearman's correlation coefficients among the different measurements at baseline and follow-up scans. Assuming tumour volume by planimetry as the reference standard, the ellipsoid formula showed the highest correlation both at baseline (ρ = 0.97 [95% confidence intervals: 0.96–0.98]) and follow-up (ρ = 0.98 [95% confidence intervals: 0.97–0.98]) imaging, followed by the biaxial measurement and, lastly, by the single maximum diameter.

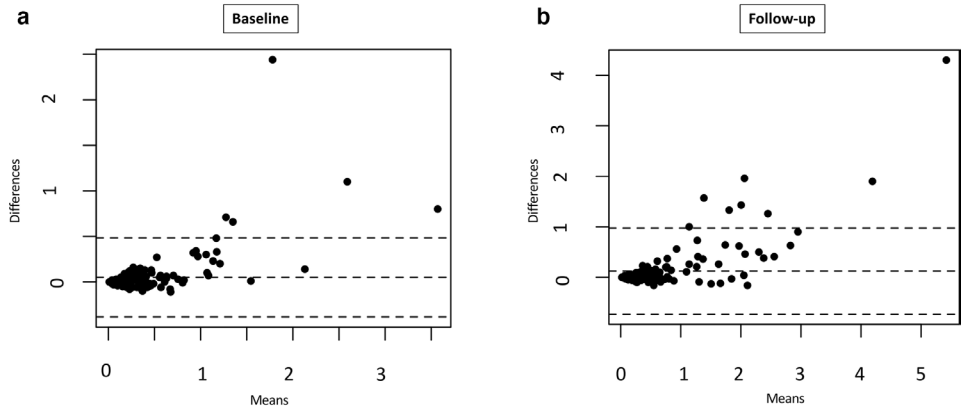
The relationship between tumour volume by planimetry and the ellipsoid formula at each time point is corroborated by the Bland–Altman plots in Figure 3, indicating low bias and narrow limits of agreement.

Table 3. Spearman's correlation coefficients among the different measurements

	Baseline mpMRI				Follow-up mpMRI			
	Planimetry	Ellipsoid	Biaxial	Maximum diameter	Planimetry	Ellipsoid	Biaxial	Maximum diameter
Planimetry	1	0.97 [0.96–0.98]	0.88 [0.84–0.92]	0.85 [0.80–0.90]	1	0.98 [0.97–0.98]	0.88 [0.83–0.93]	0.87 [0.82–0.92]
Ellipsoid	0.97 [0.96–0.98]	1	0.87 [0.83–0.92]	0.86 [0.81–0.91]	0.98 [0.97–0.98]	1	0.88 [0.83–0.93]	0.88 [0.83–0.93]
Biaxial	0.88 [0.84–0.92]	0.87 [0.83–0.92]	1	0.94 [0.92–0.96]	0.88 [0.83–0.93]	0.88 [0.83–0.93]	1	0.96 [0.95–0.98]
Maximum diameter	0.85 [0.80–0.90]	0.86 [0.81–0.91]	0.94 [0.92–0.96]	1	0.87 [0.82–0.92]	0.88 [0.83–0.93]	0.96 [0.95–0.98]	1

MpMRI, multiparametric magnetic resonance imaging.
Interquartile ranges in brackets

Figure 3. Bland–Altman plots showing the relationship between tumour volume by planimetry and by the ellipsoid formula both at baseline (a) and at follow-up imaging (b). The centre line is the mean of the differences and the top and bottom lines represent the limits of agreement (± 1.96 times the standard deviation).



The median values for the four different measurements at each time point stratified by radiological regression/stability (PRECISE 2–3) and radiological progression (PRECISE 4–5) are listed in Table 4.

Secondary outcome

Table 5 shows the average yearly percentage volume change between baseline and follow-up scans stratified by radiological regression/stability (PRECISE 2–3) and radiological progression (PRECISE 4–5) for the four different measurements. In particular, there was a significant difference ($p < 0.001$) for planimetry and the ellipsoid formula, with patients classified as PRECISE 2 and 3 showing a reduction in size over time (−3.51% and −3.06%, respectively) compared to a significant increase in size (36.13 and 43.72%, respectively) for patients with radiological progression (*i.e.* PRECISE 4 and 5), with a difference between groups of 39.64% for planimetry and 46.78% for the ellipsoid formula.

The waterfall plots in Figure 4 graphically display the growth rate expressed in years for both definitions, stratified by each PRECISE score and by subgroup (PRECISE 2-3 *vs* PRECISE 4-5).

A case of radiological stability (PRECISE 3) and a case of radiological progression (PRECISE 5) are shown in Figures 5 and 6, respectively.

DISCUSSION

We compared three different measurements for assessing tumour size on serial mpMRI in patients on AS for low- or intermediate-risk PCa diagnosed by targeted biopsy using tumour volume by planimetry as the reference standard. We found that the ellipsoid

Table 4. Median values according to the four different measurements at baseline and follow-up scans stratified by radiological regression/stability (PRECISE 2-3) and radiological progression (PRECISE 4-5)

	PRECISE score 2–3 ($n = 65$)	PRECISE score 4–5 ($n = 131$)	p
Baseline mpMRI			
Planimetry (cc)	0.17 [0.12–0.33]	0.18 [0.1–0.31]	0.50
Ellipsoid formula (cc)	0.16 [0.12–0.41]	0.17 [0.09–0.33]	0.51
Biaxial (mm^2)	0.68 [0.38–1.27]	0.62 [0.44–1]	0.48
Maximum diameter (mm)	1 [0.69–1.34]	0.90 [0.68–1.17]	0.40
Follow-up mpMRI			
Planimetry (cc)	0.17 [0.10–0.29]	0.40 [0.20–0.70]	<0.001
Ellipsoid formula (cc)	0.18 [0.09–0.29]	0.44 [0.19–0.78]	<0.001
Biaxial (mm^2)	0.73 [0.38–1.01]	1.07 [0.71–0.81]	<0.001
Maximum diameter (mm)	0.53 [0.62–1.15]	1.17 [0.86–1.73]	<0.001

MpMRI, multiparametric magnetic resonance imaging.
Data are medians with interquartile ranges in brackets.

Table 5. Average yearly percentage volume change between baseline and follow-up scans stratified by radiological regression/stability (PRECISE 2-3) and radiological progression (PRECISE 4-5)

Volume definition	PRECISE score 2–3 (n = 65)	PRECISE score 4–5 (n = 131)	p
Planimetry (%)	-3.51 [-10.45–13.02]	36.13 [11.83–89.07]	<0.001
Ellipsoid formula (%)	-3.06 [-14.28–15.36]	43.72 [15.19–109.64]	<0.001
Biaxial (%)	-0.54 [-7.50–15.77]	24.28 [7.42–53.29]	<0.001
Maximum diameter (%)	0.06 [-8.31–10.69]	12.90 [3.73–25.59]	<0.001

Data are medians with confidence intervals in brackets. Analysis of variance (Kruskal–Wallis test) is p = 0.76 and p <0.001 for PRECISE 2–3 and PRECISE 4–5, respectively.

formula was the method with the highest correlation at baseline and follow-up mpMRI (ρ = 0.97 and ρ = 0.98, respectively) and that the average yearly percentage volume change for both measurements (planimetry and ellipsoid formula) was significantly different (p < 0.001) according to radiological change expressed by the PRECISE scoring system.

The PI-RADS v. 2.1 steering committee has outlined that that there can be differences in lesion size on the various mpMRI pulse sequences, highlighting the need of further investigations at this regard.[16] However, in order to standardise the measurements, both the PI-RADS v. 2.1 steering committee and the panelists of the PRECISE working group agreed that the minimum requirement is to report the largest dimension of a suspicious lesion (on an axial image or on the image that best depicts the finding if the lesion is not clearly delineated on the axial image).[13] Alternatively, lesion size and volume can be determined using the other definitions that we have applied in this study.

We acknowledge that the PI-RADS v. 2.1 guidelines[16] suggest that lesions should be measured on the dominant sequence according to tumour location but at the same time, it is also recommended that measurements should be made on the sequence that shows the lesion best if the measurement is difficult or compromised on the dominant sequence.

We deliberately focused this study on data from T_2WI to ensure the most accurate calculation of each single diameter in the analysis, as T_2WI is the only sequence where two orthogonal planes are acquired, as per PI-RADS v. 2.1 guidelines.[16] We believe that for the purpose of this study, such strategy is more accurate than calculating for example the longitudinal diameter by multiplying the slice thickness by the number of slices containing any tumour, as the slice thickness can differ between sequences according to PI-RADS v. 2.1 guidelines.[16] In addition to this, we know that many small, low-risk tumours on AS are either equivocally seen or not seen at all on the different sequences.[20]

This guaranteed consistency in terms of lesion conspicuity for the different measurements and ensured a detailed visualisation of prostate anatomy and an optimal soft tissue contrast at the same time that helped to distinguish between genuine lesions and partial volume averaging effects.

Le Nobin and colleagues[11] have reported that DWI could lead to tumour volume underestimation compared to T_2WI using radical prostatectomies as the reference standard, especially for tumours with a higher Gleason score. A possible explanation is that more aggressive tumours are more conspicuous on DWI due to the higher degree of restriction, and this could result in the underestimation of the real tumour volume on mpMRI due to the exclusion of any non-visible surrounding low-grade tumour.

In addition to this, there is yet no consensus to determine which method for measuring tumour size is optimal to distinguish between radiological regression/stability or progression on AS. During the PRECISE consensus meeting,[13] concern was expressed that the measurement errors of small lesions could be

Figure 4. Waterfall plot showing the different tumour growth rate per year (expressed as percentage) according to PRECISE score (PRECISE 2–3 *vs* PRECISE 4–5) for tumour volume by planimetry (a) and by ellipsoid formula (b).

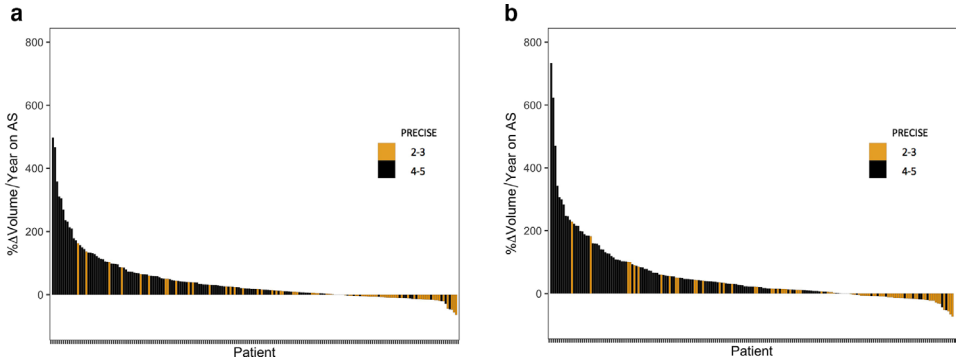
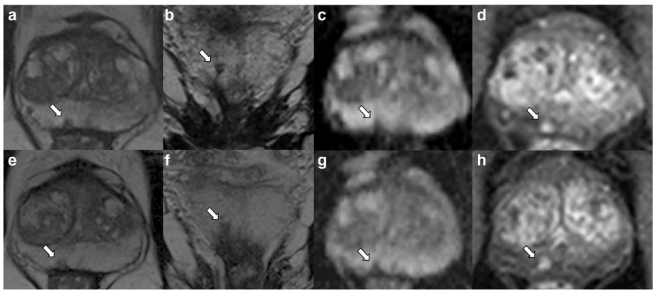


Figure 5. 64-year-old patient. Baseline PSA is 6.40 ng ml^{-1} and baseline mpMRI shows a prostate of 69cc (PSA density: 0.09 ng/ml ml^{-1}). There is a suspicious focus (arrows) of reduced signal on axial (a) and coronal (b) T_2WI, restricted diffusion on the ADC map (c) and early enhancement on DCE sequences (d) in the mid-basal right peripheral zone at 7 o'clock (PI-RADS 4). Both lesion volumes (by planimetry and using the ellipsoid formula) are 0.06 cc. Targeted biopsy reveals 2 mm Gleason 3 + 3 prostate cancer and the patient is managed with active surveillance. At 1 year follow-up mpMRI, the PSA is stable (6 ng ml^{-1}) and the prostate volume is 70 cc (PSA density: 0.09 ng/ml ml^{-1}). There are no significant changes in lesion size and conspicuity on axial and coronal T_2WI (e and f), on the ADC map (g) and on DCE sequences (h). The volumes by planimetry and using the ellipsoid formula are 0.05 and 0.06 cc, respectively.

The PRECISE score for this patient is 3, as there are no signs of radiological change over time.



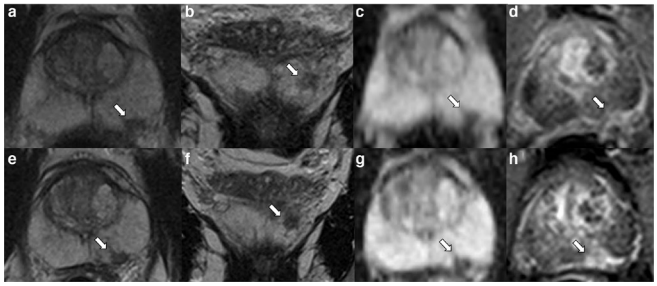
larger than any change, even if significant in percentage terms. This is something that needs to be taken into account when looking at AS cohorts, and this is why we applied a very stringent entry criterion for this work (*i.e.* we analysed only mpMRI-visible lesions confirmed by targeted biopsy).

We also know that mpMRI can overestimate tumour volume for small or low-grade disease (especially during AS), as small lesions are often surrounded by areas of high-grade prostate intraepithelial neoplasia or areas of inflammation/atrophy that can mimic low-grade cancer, resulting in false-positive findings on mpMRI.[21]

Marin and colleagues[2] assessed the accuracy of manual semi-automated and volumetric measurements to assess PCa volume on mpMRI in 30 patients using whole-mount histopathology as the reference standard. Two radiologists, independently, assessed the maximum tumour diameter along with tumour volume by planimetry and using the ellipsoid formula. In line with our results, they found a good correlation between readers for the ellipsoid formula and for planimetry (ρ = 0.78 and ρ = 0.79, respectively). They also found that the maximum tumour diameter provided the highest correlation with the maximum histologic diameter (ρ = 0.98 and ρ = 0.79 for the two readers).

To our knowledge, our study represents the first attempt to compare four different measurement methods of the index lesion in patients with PCa on AS and to investigate the relationship between tumour growth rate on serial mpMRI and the PRECISE score.

Figure 6. 51-year-old patient. Baseline PSA is 4.8 ng ml^{-1} and baseline mpMRI shows a prostate of 32 cc (PSA density: 0.15 ng/ml ml^{-1}). There is a suspicious focus (arrows) of reduced signal on axial (a) and coronal (b) T_2WI, restricted diffusion on the ADC map (c) and mild enhancement on DCE sequences (d) in the left basal peripheral zone between 4 and 5 o'clock (PI-RADS 4). The volumes by planimetry and using the ellipsoid formula are 0.9 and 0.8 cc, respectively. Targeted biopsy reveals 4 mm Gleason 3 + 4 prostate cancer and the patient opts for active surveillance. On the latest mpMRI scan (3 years later), the PSA has increased to 5.40 ng ml^{-1} and the prostate volume is 31 cc (PSA density: 0.17 ng/ml ml^{-1}). The edges of the lesion are sharper and there has been an increase in size and consipicuity on axial (e) and coronal (f) T_2WI with clear abutment of the prostatic capsule, on the ADC map (g) and on DCE sequences (h), where the lesion is now clearly visible and capsular enhancement is also noted, suggesting capsular involvement. Subsequent targeted biopsy reveals 8mm Gleason 4 + 3 prostate cancer and the patient is treated with radical prostatectomy. Final histology confirms pT3a disease with a maximal Gleason score of 4 + 3.The PRECISE score for this patient is 5, as there has been an increase in size and conspicuity of the lesion associated with radiological stage progression.



We found that the ellipsoid formula was a good method to assess tumour volume in a cohort of patients with PCa diagnosed by targeted biopsy. We believe that this result adds to current literature, as it is known that contouring lesions by planimetry is the most accurate method to define imaging-based PCa volume, but this method is highly time consuming, especially during daily clinical practice. Furthermore, we know that sometimes very small lesions (and this is a common scenario during AS) can be seen only on one or two slices and obtaining a diameter rather than conducting a proper lesion segmentation by planimetry is easier.

Although the choice of a targeted biopsy as proxy for ground truth rather than the pathological specimen could be seen as a limitation of our study, it should be kept in mind that the aim of AS it to defer any form of active treatment until there are signs of more aggressive disease, and therefore it is not possible to obtain whole-mount histology from radical prostatectomies for the majority of the patients in our AS cohort. Additionally, this would have introduced a clear bias in the study, as it is highly likely that almost all patients would have shown radiological

progression (*i.e.* PRECISE 4 or 5). In order to avoid any ascertainment bias but also to be as much closer as possible to a valid reference standard, we applied the most stringent entry criterion for an AS cohort and included only patients with a visible lesion confirmed by targeted biopsy.

A limitation of our study is that only a single radiologist, although highly experienced in prostate mpMRI reporting, performed all calculations and applied the PRECISE score,[22] therefore we cannot comment on measurement error at present. However, it has been reported a moderate interreader agreement for planimetric evaluation of prostate lesions on mpMRI with no significant differences in the agreement for T_2WI, DWI and DCE segmentations.[23] In addition to this, a substantial reproducibility of the PRECISE scoring system has been recently shown between two expert radiologists, especially when data are pooled together according to the absence or presence of radiological progression, as in our study.[24] We acknowledge that the correlation with the PRECISE scoring system could be seen of limited value at present, as radiological progression is one of the drivers to active treatment in our AS cohort. Our initial results should be seen as a first attempt to explore the relationship between changes in lesion size on mpMRI and radiological changes by means of PRECISE score, as called for by the panellists who drafted the PRECISE recommendations.

Also, the design of our study does not allow to comment on those patients without measurable lesions (*e.g.* ill-defined, diffuse changes with blurred margins where it is difficult to accurately place calipers for measurements). A clear definition of ill-defined lesions during AS will be a major focus of the next set of the PRECISE recommendations.

Lastly, some patients received scans on both 1.5 and 3 T scanners, and this may have limited the ability to accurately compare measurements of lesions between scans. However, we compared measurements that were obtained exclusively from T_2WI, and the acquisition protocol for T_2WI at our centre was the same for both magnets (*e.g.* in terms of slice thickness and in-plane resolution), differently from the conduct of DWI for example (where we use two different *b* values according to the magnet field).

CONCLUSION

In conclusion, our study suggests that the ellipsoid formula is strongly correlated with planimetry and could be used to monitor tumour growth on mpMRI during AS. This is further corroborated by the significant difference in the average yearly percentage volume change over time stratified by radiological regression/stability (PRECISE 2–3) and radiological progression (PRECISE 4–5) for both definitions. Tumour volume using the ellipsoid formula should be recorded in AS cohorts, as this approach is relatively straightforward to implement in a clinical workflow compared to planimetry.

DISCLOSURE

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