11. Realignment of prostate position

- The antero-posterior position of the prostate needs to be realigned. In the transverse views, identify the base plane with the ultrasound probe and planning computer, then scroll the probe into the middle of the gland and adjust the position of the prostate on the planning computer to align with the gland on the ultrasound.

- The central needle positions are then transferred from the planning computer to the ultrasound screen.

12. Central needle and seed insertion

- The central needles are then all inserted in the transverse view. Once complete switch to the longitudinal views and starting with the anterior needles, insert the loose seeds with the Mick applicator using ultrasound probe retraction planes, or create bespoke strands via the Isoloader as previously calculated.

- Before the centre (D column) seeds/strand is inserted reassess the urethral position by inserting the foley catheter to ensure the dosimetry is optimised, especially at the apex of the gland.

13. Post implant dosimetry check

- When all the seeds are inserted, switch to the transverse view, align both the ultrasound and the planning computer at the base and scroll through the prostate to assess the isodose curves. Determine whether any further seeds are required to complete the implant.

13. Assess for haematuria

- At the end of the procedure, insert the catheter and inflate the balloon, then withdraw the aerated gel to ensure there is minimal haematuria.

Technical steps for a successful implant

BXTAccelyon®

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4D Brachytherapy

1. Planning scan

- Ensure prostate is not compressed, with posterior pressure of probe towards sacrum.
- Assess for significant middle lobe.
- Measure maximum height and width in transverse plane (A), length (B) and 2 para sagittal distances (C) in longitudinal plane parallel to the probe.
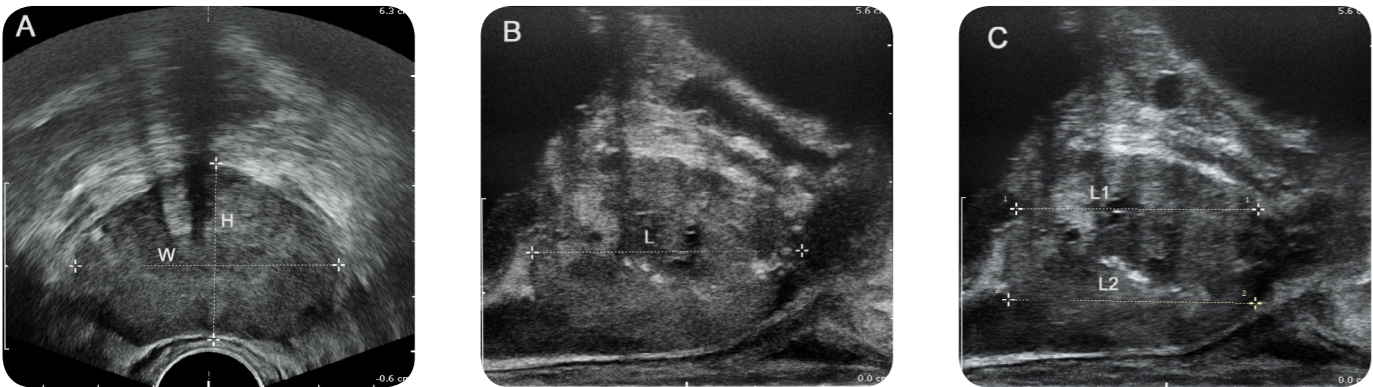
The above five measurements may be obtained from T2 MRI images of the prostate. However, ensure the transverse view has been obtained perpendicular to the longitudinal view otherwise the height and possibly width may be overestimated. Care must also be taken to correctly identifying the apex of the gland in the MRI view. The best correlation between U/S and MRI measurements is seen with glands less than 40cc. In patients where the MRI measurements are used to generate the seed order, it is recommended that a check U/S be performed prior to the implant procedure to verify the seed requirement.

2. Patient set up

- Legs flexed to 100°, to minimise arch interference. Ensure pelvis and spine are straight.
- Ensure rectum is empty and insert diclofenac suppository, if to be used, high in the rectum.
- Ensure the absence of air bubbles in balloon and optimise the acoustic contact between the probe and inner aspect of balloon, outer aspect of balloon and condom, and condom and rectal wall - assessed on ultrasound images. Do not proceed until this is optimised.
- Assess for pubic arch interference in transverse plane and adjust leg position and probe angle from starting position of 6° down to flat or 6° up, if required.
- Position 16G foley catheter into bladder with balloon deflated.

3. Volume study

- Ensure prostate is symmetrical about D column, and not compressed. Posterior border of gland may be up to 5mm below 1.0 Row.
- Measure the maximal length in the longitudinal plane, then identify the base in the transverse plane and scroll through the prostate from base to apex to ensure the length is in agreement with the previous measurement.
- Draw round prostate on each transverse image, starting at 12 o'clock position recording the images from the base to the apex on the planning computer in 5mm steps. Alternatively record images and directly draw using the planning software.
- Review the recorded images in the longitudinal plane on both the planning computer and ultrasound to ensure alignment. Where discrepancies occur adjust one or more of the recorded transverse images until close alignment is obtained.
- Aerated gel is inserted through the urethral catheter as the catheter is withdrawn, so detailing the prostatic urethra. The prostatic urethra is then contoured in the longitudinal view.

4. Alignment of seed order to prostate shape

- In the transverse view on the planning computer, using the uploaded needle and seed order, identify the largest prostate image, (maximum perimeter), and move the needle positions so they are spaced evenly around the perimeter. Keep the approximate configuration of four needles across both the anterior (top) and posterior (bottom) portion of the gland. The central loose needles are then spaced in the standard fashion within the centre of the gland.
- Review the calculated dosimetry ensuring the isodose curves cover the entire gland and adjust the needle positions as required. If the predicted dose to the prostate is too high despite adjusting the number of central sources, remove two lateral or one posterior peripheral stranded needles. Do not implant any seeds until a satisfactory dosimetry is obtained.
- The needle positions are then transferred from the planning computer to the ultrasound screen.

  (Technical Note: Positioning the stranded needles:

  If the perimeter of the prostate is larger than expected and it is difficult to cover the prostate outer edge of the gland with the 100% isodose, move the posterior needles such that a wider than usual space is created between the middle two needles. In doing this the rest of the needles can be better spaced around the perimeter to optimise the 100% isodose coverage. The "cold" under dosed area posteriorly that is created can be managed by using an extra central needle to ensure the dosimetry is optimised.)

5. Completion of contouring

- 4D Brachytherapy is a two operator procedure, so the computer operator contours the anterior rectal wall then begins optimising the central needle and seed positions to obtain the optimal dosimetry according with the prescription. During this time the second operator begins inserting the preloaded stranded needles leaving the needle tip in the mid-gland region.

6. Peripheral needle insertion

- The second operator begins inserting the preloaded stranded needles in order, in the transverse plane. When the anterior and lateral needles are all inserted, the positions are verified on the planning computer and the dosimetry checked before any seeds are inserted.

7. Stranded seed insertion

- Working in the longitudinal plane the base plane is verified and any adjustment of the prostate position on the planning computer in the antero-posterior plane (y axis) is made.
- The computer operator moves the cradle to focus on each needle in turn beginning with the anterior 4 needles then moving to the lateral needles. When each needle is identified on both the ultrasound and planning computer, the second operator advances the needle to the base of the prostate and the seeds are then deployed and their position recorded on the planning computer.

  (Technical note: In the lateral needles the needle tip will often be caudal to the prostate outline depending on the shape of the prostate)

  (Technical note: The posterior lateral strands especially, may move laterally having been deployed from their needle. Therefore, move the U/S cradle to ensure the image and therefore position is optimized before recording the strand position of the planning computer.)

  (Technical note: If a haematoma develops, typically when inserting the postero-lateral needles, stop. Raise the ultrasound probe anteriorly, when fully inserted, using the stepping unit. This will cause compression of the prostate, stop the bleeding and will allow the haematoma to disperse. Leave for 10 minutes before re-positioning the ultrasound probe and completing the procedure.)

8. Insertion of posterior needles

- Having inserted the anterior and lateral strands, the remaining four posterior needles are inserted. During this time further dosimetry optimisation is undertaken on the planning computer. Insert the middle two needles first, usually starting on the 1.5 row, which will help bring the prostate anteriorly to aid needle position if the posterior border of the prostate is below the 1.0 row.
- To account for the anterior movement of the prostate due to the insertion of the posterior four needles, align both the ultrasound and the planning computer in the transverse view at the zero plane. Scroll the U/S probe through to the middle of the prostate and move the image on the planning computer to obtain alignment. Following this movement align the planned needles to the inserted needles.
- Then switch to the longitudinal plane for both the U/S and planning computer, and again move the prostate outline on the planning computer anteriorly, to align with the position of the gland and the needles on U/S. The base plane must also be checked and adjusted at this stage as well.

9. Insertion of posterior seeds

- The posterior strands are then inserted up to the base of the prostate and their positions recorded on the planning computer. Leave the ultrasound probe fully inserted whilst the final dose planning is completed to disperse any bleeding that may have occurred.

10. Completion of dose planning

- The dose planning is completed using the dose constrains below. At this time assess where the bulk of the cancer is situated and ensure, if possible this is covered by the 150% isodose.

Theatre Intra-operative tolerances

Organ	Dosimetric parameter	Full: 145 Gy	Boost: 110Gy
Prostate	V100% (%)	>98	>98
	V150% (%)	40-60	40-60
	D90% (Gy)	175-180	132-137
Urethra	D30% (%)	<125	<125
	D5% (%)	<150	<150
Rectum	V100% (cc)	<1	<1

(Technical note: Planning the central needles.

1. *When using loose seeds, have two seeds at the base for the anterior two needles, in case one inadvertently passes into the bladder.*
2. *When using loose seeds try and avoid planning with three or more seeds together as small misplacements of the initial two seeds will lead to the last seed/s being significantly out of position. This is less of an issue using stranded seeds created by the Isoloader).*