Three-dimensional Elastic Augmented-reality Robot-assisted Radical Prostatectomy Using Hyperaccuracy Three-dimensional Reconstruction Technology: A Step Further in the Identification of Capsular Involvement

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3D ELASTIC AUGMENTED-REALITY ROBOT-ASSISTED RADICAL PROSTATECTOMY USING HYPER-ACCURACY THREE-DIMENSIONAL RECONSTRUCTION (HA3D™) TECHNOLOGY TO IDENTIFY SUSPICIOUS CAPSULAR INVOLVEMENT DURING DISSECTION OF PERIPROSTATIC TISSUE: A STEP FURTHER IN IMAGE GUIDED SURGERY

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ABSTRACT

Background: in prostate cancer (PCa) surgical procedures in order to maximize the potency recovery, a nerve-sparing (NS) procedure is preferred. However, cancer abutting or focally extending beyond the prostate capsule increases the risk of a positive surgical margin.

Objectives: to evaluate the accuracy of our new 3D Elastic Augmented Reality (AR) system in identifying capsular involvement (CI) of PCa during the NS phase of RARP. Secondarily the accuracy of this technology was compared with 2D based cognitive procedures.

Design, setting and participants: prospective study, enrolling patients with prostate cancer undergoing RARP at our centre, from May to October 2018.

Surgical procedures: RARP with TAR was performed in all the cases. Moreover, the 3D Elastic AR images was overlapped during the NS phase in order to identify the suspicious lesions.

Measurements: Clinical data were collected. The patients enrolled underwent to 3D AR-RARP or, in case of unviability of this technology, to 2D Cognitive RARP. A metallic clip was placed at the level of suspicious CI on the basis of images given by the 3D AR images or by MRI report. The pathological analysis evaluated the presence of tumour at the level of the clip.

Results and limitations: 40 patients were enrolled, 20 for each group. Focusing on 3D AR Group at macroscopic evaluation the metallic clip was placed at the level of the tumour and capsular bulging in all the cases. At microscopic assessment cancer presence was confirmed at the level of the suspicious area in 95.4% of the cases. Moreover, the CI was correctly identified in 100.0% of the cases. These results were compared with the one of 2D MRI Cognitive Group showing a statistically significant superiority of the 3D AR Group in CI detection during the NS phase. The main limitation of this technique is that the segmentation and the overlapping of the images are performed manually.

Conclusions: Our findings suggest that, with the introduction of the elastic 3D virtual models, prostate deformation is correctly simulated during surgery, and lesion location is correctly identified, even if in a dynamic reality with a subsequent potential reduction of positive surgical margin rate and, in the meantime, a maximization of the functional outcomes.

Patients summary: on the basis of our findings, the 3D Elastic AR technology seems to help the surgeon in lesion location identification even in a dynamic phase of the intervention, optimizing the oncological outcomes and, in the meantime, a maximization of the functional ones.

1 Introduction

In order to maximize the potency recovery after robot-assisted radical prostatectomy (RARP), a nerve-sparing (NS) procedure is preferred. A fine balance between the maximum amount of nerves fibres preserved and the risk of positive surgical margins (PSMs) is required, considering that cancer abutting or focally extending beyond the prostate capsule increases this risk [1].

Up to now, in order to help the surgeon in intraoperative lesion identification, many experiments with molecular-imaging guided surgery have been performed with the aim to recognize hidden tumor, but without clear clinical application [2].

Thus, intraoperative knowledge of the three-dimensional (3D) location of cancer lesion can prevent the surgeon from conceptualizing the procedure based on 2D preoperative images, potentially reducing this risk [3].

In this setting, we already developed the Hyper-Accuracy 3D reconstruction (HA3D^{TM}) technology [4] obtaining detailed 3D virtual models of the prostate that highlight the tumor and its relationship with prostate capsule. Moreover, we already reported a preliminary experience with Augmented-Reality (AR) RARP [5], proving the accuracy of images overlapping in a static phase of the intervention.

The need to identify the lesion and its relationship with the prostate capsule mainly during the dissection phase of the intervention, has led us to a further development of this technology, creating models to be superimposed even in the dynamic phase.

In this study, we specifically developed an Elastic AR system based on elastic HA3D^{TM} model that simulates prostate deformation due to the grasping exercised by robotic arms during the intervention.

The aim of this study is to evaluate the accuracy of our new 3D Elastic AR system in identifying capsular involvement (CI) of PCa during the NS phase of RARP. Secondarily the accuracy of this technology was compared with 2D based cognitive procedure.

2 Materials & Methods

2.1 Study population and Hyper-Accuracy 3D Reconstruction (HA3D^{TM}) processing

This was a prospective study, enrolling patients with prostate cancer (clinical stages cT1-3, cN0, cM0) undergoing RARP at our centre, from May to October 2018. The study was conducted in accordance with good clinical practice guidelines, and informed consent was obtained from the patients.

In all cases, prostate cancer diagnosis was based on a positive target biopsy at the index lesion [6]. Preoperative assessment included a high-resolution (1 mm slices) mp-MRI according to a dedicated protocol, as previously described [3]. Only patients with index lesion with suspicious CI at mp-MRI were enrolled in this study.

The images in DICOM format were processed by dedicated software, authorized for medical use by MEDICS Srl (www.medics3d.com), in order to perform the HA3D^{TM} reconstruction as we already described [3]. The final output was in STL format.

On the basis of the availability of this technology at our Institution the patients were scheduled for 3D Elastic AR-RARP or for 2D Cognitive RARP.

2.2 ***3D Elastic Augmented Reality***

A specific system was used to overlay virtual data on the endoscopic video displayed by remote Da Vinci surgical console (Intuitive, Sunnyvale, CA, USA).

The HA3D^{TM} virtual model of the prostate was loaded by the *pViewer* application as we previously described [5]. This software was developed using the Unity platform [7] and C Sharp [8], and was specifically engineered to display a 3D model of patient's prostate and to control its translation, rotation, and scale transformation values.

To improve the overlay precision, considering the prostate elasticity and deformation due to grasping and traction forces of the robotics arm during the intervention, we tried to simulate these forces with our *pViewer.*

The first challenge was addressed by approximating the deformation of the target organ by applying non-linear parametric deformations [9] to the 3D model meshes. Using parametric transformation formulas, it was possible to twist, bend, stretch and taper the model. All these transformations were described along one main axis, and could be summed together in order to combine deform effects. Using Barr's formulas gave us fast and intuitive manipulations, with little computational effort and good visual results.

Among the available parametric deformations, we selected bend (Fig. 1) and stretch (Fig. 2) as those most suited to our visualization and overlay purposes. Since the prostate virtual model is composed of multiple meshes, in order to apply the formula uniformly to all of them, we used the method introduced by Thomas and colleagues [10].

Finally, in order to solve the issue of a realistic deformation *in vivo*, we opted for a human-assisted deformation by using a 3D professional mouse.

Moreover, by pressing a keyboard button, it is possible to switch the input device from using its axes for movement, rotation, and scale, to using the axes to apply forces to the hull of the parametric deformation.

Then, the video rendered by the *pViewer* application was mixed with the video taken by the endoscopic camera using a software video mixer application. The resulting stream was then sent back to the DaVinci remote console monitor in real time, where it was used by the surgeon as needed by means of TilePro™ multi-input display technology.

2.3 ***3D Elastic AR-RARP procedure***

All RARP procedures were performed by a single highly experienced robotic surgeon (FP), according to a previously described technique [11]. The AR technology was used in four standardized key steps during the procedure, as previously reported [4].

For the purpose of the present study, the virtual image of the prostate was overlapped onto endoscopic view by using the Tile-Pro. Our markers to guide a precise manual overlapping were the prostate apex, the prostate landmarks, and the catheter.

The innovation in this study is that the superimposed 3D virtual model was stretched and bended according to the traction exercised on the prostate by the robotic arms, allowing a dynamic chasing of prostate movement and deformation during the procedure. In order to gain the best exposure of the tumor and the suspicious CI during the nerve-sparing phase of the intervention, if it was located on the anterior or antero-lateral side of the prostate, the virtual model was stretched and minimally bend on the sagittal axis from front to back (Fig. 3); if the lesion was posterior or postero-lateral, the model was stretched and mainly bend from back to front (Fig. 4).

Therefore, the CI location resulted in being clearly visible on the surface of the opaque 3D virtual prostate model, irrespective of its location; then, the suspicious area of CI was marked on the prostate capsule with a metallic clip (Fig. 5).

Finally, according to pre-surgical indications, a partial or minimal nerve sparing (NS) procedure was carried out.

2.4 ***2D Cognitive procedure***

In case of 3D AR technology unavailability, the patients included in this study were scheduled for 2D Cognitive procedures. In the details, during the intervention, the surgeon had the possibility to visualize the location of the tumor and CI drawn on the segmentation model used in PI-RADS ^{TM} v.2 [12].

During the dissection phase of the intervention, at the level of suspicious lesion and CI, as indicated by the MRI, the surgeon applied a metallic clip in order to identify the underlying tumor.

2.5 ***Histopathological evaluation***

At histopathological evaluation, whole-mount histological sections were used as the reference standard. The prostate surface was marked with black ink, whilst, at the metallic clip applied intraoperatively, red and green inks were used. Then, the prostate was cut according to a previously reported method [13,14], modified to get 3-mm thick sections. A first evaluation of the presence of the tumor and bulging at the metallic clips was done during the reduction phase. Then, after a routine histologic process, 5-µm sections were taken from each thick slice and stained with haematoxylin and eosin. All samples were then assessed for cancer foci by an experienced uro-pathology team (F.M., D.T., and E.B). The tumor volume of each node was calculated as previously described [13]. The pathologist also assessed the pathological Gleason score [15] for each focus and specified the presence or absence of prostatic CI as previously described [16], in particular under the red and green inks.

Classification of capsular involvement was assigned according to pathological Wheeler [16].

2.6 ***Data analysis***

Collected data included demographic variables, for the analysis of the mp-MRI, the Prostate Imaging– Reporting and Data System (PI-RADS) classification was used to describe the lesions found [12]; the lesions' location and the presence of ECE were recorded. Classification of capsular involvement was assigned according to radiological Wheeler [17].

Intraoperative variables, including estimated blood loss, skin-to-skin operative time, extended pelvic lymph-nodes dissection (ePLD) rate and number of full, partial, and minimal nerve-sparing (NS) procedures (according to Pasadena's classification [18]) were recorded.

Postoperative variables, such as duration of catheterization and hospitalization time, and postoperative complications (graded according to Clavien-Dindo [19]), were evaluated.

Pathological variables, including classification of capsular involvement according to pathological Wheeler [16] were recorded. Specifically, for the purpose of this study, the correspondence of the metallic clip placed on the prostate capsule with the underlying tumor location and the ECE postion was evaluated.

2.7 ***Statistical analysis***

Means and standard deviations (SDs) and interquartile ranges (IQRs) were used to describe continuous variables. Categorical variables were summarised by frequency tables.

To verify the comparability between the 3D AR RARP group and 2D Cognitive RARP group, baseline variables were evaluated, testing the differences of quantitative and categorical variables with nonparametric Mann–Whitney and chi-squared tests, respectively

The inter-rater agreement for quality (categorical) items was expressed by Cohen’s kappa coefficient.Data were analyzed by StatSoft v.10.

3. Results

3.1. Demographics and perioperative outcomes

40 patients were enrolled in the present study. 20 patients underwent 3D Elastic AR RARP, whereas 20 underwent 2D Cognitive procedure. Preoperative variables are summarized in Table 1. mp-MRI revealed 4 (18.1%) and 4 (17.4%) lesions with PIRADS ≤ 3 and 18 (81.8%) and 19 (82.6%) lesions > 3 in the 3D AR group and 2D cognitive group respectively.
The mean lesion volume at mp-MRI was 4.4 cc (+\- 2.1) for the 3D AR Group and 4.1 cc (+\- 2.4) for the 2D Cognitive group (p=: 0.67).

In patients who underwent 3D AR procedures, in 5 (22.7.0%) cases the CI recorded at mp-MRI had a score ≤ 2 according to Wheeler, whilst in 17 (77.2%) cases was ≥ 3F (Table 2).
In the 2D Cognitive group the CI revealed a score ≤ 2 according to Wheeler in 7 (30.4%) cases whilst in 16 (69.6%) cases was ≥ 3F (Table 2).
Intraoperative and postoperative data are detailed in Table 3.

3.2. Pathological findings

Histopathological data are reported in Table 4.
Compared to pathological evaluation, mp-MRI correctly classified suspicious CI (Wheeler ≤L2 or ≥ 3L) in 19\22 (86,3%) cases in 3D AR group with a Cohen's kappa coefficient 0.67; whilst in 20\23 (86.9%) cases in 2D Cognitive Group with a Cohen's kappa coefficient 0.72.
At macroscopic evaluation the metallic clip was placed at the level of tumor in 22/22 (100%) and 20\23 (86.9%) cases in 3D AR group and 2D Cognitive group respectively (p= 0.24).
In particular the marker was placed at the level of suspicious capsular bulging in 22/22 (100%) and 18\23 (78.2%) cases for each group (p= 0.06). (Fig. 6a; Fig. 6b).
Subsequently, microscopic assessment was performed. It confirmed cancer presence in 21/22 (95.4%) and 19\23 (82.6%) cases at the suspicious area identified by the 3D elastic overlap or 2D cognitive template respectively (p= 0.37). Moreover, CI was correctly identified in 15/15 (100.0%) in the 3D AR group and in 8\17 (47.0%) of cases in 2D Cognitive group (p= < 0.05) (Fig. 6c; Fig. 6d).

4. Discussion

Recent advances in 3D reconstruction from digitalized images now make it possible to provide intraoperative surgical navigation [20 - 22] and different authors reported their experience with the use of AR during prostate surgery in laparoscopy and anecdotally in robotics [23 - 25].

In order to contribute to this field, our group realized and published a preliminary experience of AR RARP [4, 26]. The innovation in that study is the software-based integration of the virtual model inside the Da Vinci (Intuitive, Sunnyvale, CA, USA) robotic console during robotic prostatectomy. The virtual image overlapping the endoscopic view correctly identified the tumour location in all the cases [5].

However, these techniques utilized rigid prostate models. These rigid and static views do not represent the biological realism necessary to create more functional and dynamic overlapping that may be used during the intervention.

As the real prostate is composed of soft tissues that may be deformed, there is a need to obtain an elastic model. Unfortunately, in a recent review, Payan et al. [27] reported that less than ten biomechanical modelling works used in surgical practice can be found on the market.

Indeed, three main challenges should be addressed: (1) the automatic generation of patient-specific models of organs and soft tissues, (2) the *in vivo* estimation of patient-specific constitutive laws for such tissues and (3) the real-time (or at least interactive-time) computations of these models.

Concerning the first topic, the automatic generation of patient specific models can indeed be a long and tedious task, especially when a Finite Element mesh has to be designed with constraints such as the inclusion of substructures (like vessels, glands, or muscles inside a larger organ) and the requirement of avoiding linear tetrahedral elements [28].

Concerning the second topic, an *in vivo* aspiration device that has been used intraoperatively to estimate constitutive laws has been proposed [29]. As for the third topic, a fast computation of nonlinear Finite Element models is still an unsolved question, even if some promising methods have been proposed [30].

In this scenario we introduced our 3D Elastic AR-RARP using HA3D^{TM} reconstruction thanks to the application of non-linear parametric deformations in order to approximate the deformation of the target organ. In particular, the bend deformer used the global Y axis as the main deformation axis, along two different directions, whilst the stretch deformer used the global Y axis alone.

The two deformers chosen proved to be valid in estimating prostate deformations during surgery. In fact, notwithstanding the traction exercised on the prostate by the robotic arms, thanks to the elastic 3D overlapping model, the lesion and the capsular involvement location were dynamically identified correctly during the nerve-sparing phase (100% of correct lesion identification).

Moreover, in this study emerged that the location of the suspicious lesion on the basis of the 2D images required a hard mental imagination process and the accuracy of lesion's identification wasn't accurate. In fact, in the 2D Cognitive group, the metallic clips location corresponded to the CI in 47% of cases with a statistically significant difference compared to the 3D AR group (p-value < 0,05)
This greater effort in perceiving the three-dimensionality of the organ and therefore the correct localization on the three spatial planes of the lesion resulted in a greater number of positive surgical margins in the group of patients who underwent cognitive procedures (26.6% v.s 33%).
The advantages of the 3D AR technology lead to a potential oncological benefit for patients and, consequently, a lower necessity of adjuvant therapy.
We think that this new implementation of the robotic platform can represent a new paradigm of the treatment of PCa in the "precision surgery" era [31]. The procedures can be tridimensionally modulated in real-time on the basis of patient's specific anatomy and in particular of CI location.

The current study is not devoid of limitations. First of all, the segmentation of the prostate tumours was performed manually; an experienced urologist and radiologist were necessary to complete the segmentation process. Therefore, the entire overlap process is "operator-dependent as the 3D mouse needs to be manipulated by an assistant during the procedure, to allow proper orientation and deformation of the 3D model.
The next evolution of the technology would be an automated model consolidated to organ movements during the surgery. Moreover, access to more computationally complex techniques, such as ones that simulate tissue dynamics, will allow an improvement in the quality and realism of the deformations.

Conclusions

In conclusion, our findings suggest that, with the introduction of the elastic 3D virtual models, prostate deformation is correctly simulated during surgery, and lesion location is correctly identified, even if in a dynamic reality.

This new technology allowed us to perform a 3D elastic AR-RARP, optimizing the NS tailoring with a subsequent potential reduction of positive surgical margin rate and, in the meantime, a possible maximization of the functional outcomes.

Further research is required to corroborate these early encouraging findings, and a prospective randomized study is needed to verify the real clinical advantages of 3D-AR image guided surgery.

CONFLICT OF INTEREST:

All the Authors have nothing to declare.

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TABLES

Preoperative variables

PATIENTS' CHARACTERISTICS	**Overall**	**3D Group**	**Cognitive Group**	**p-value**
Number of patients	40	20	20	
Age, mean (SD), years	67.2 (±5.9)	66.5 (±5.7)	67.33 (±5.9)	0.64
BMI, mean (SD)	25.89 (±3.1)	26.5 (±4.0)	26 (±3.6)	0.68
PSA, mean (SD), ng/ml	8.9 (±5.6)	7.6 (±3.2)	9.5 (±4.6)	0.13
ASA score, median (IQR)	2 (2-3)	2 (2-3)	2 (2-3)	0.91
IPSS score, median (IQR)	7 (0-21)	7 (0-21)	8 (0-21)	0.65
IIEF-5 score, median (IQR)	21 (17-25)	22 (17-25)	22 (17-25)	0.92
GS, median (IQR)	7 (7-8)	7 (6-9)	7 (7-8)	0.88
Positive DRE, number (%)	11 (27.5)	5 (25)	6 (30)	1.0
D'Amico classification, number (%)				
• Low risk	7 (17.5)	3 (13.6)	4 (18.2)	0.97
• Intermediate risk	15 (37.5)	12 (54.5)	13 (59.1)	0.97
• High risk	12 (30)	7 (31.8)	5 (22.7)	0.77

TABLE 1: Preoperative variables (BMI: body mass index; PSA: prostate specific antigen; ASA score: American Society of Anesthesiologist score; IPSS: International Prostate Symptoms Score; IIEF: International Index of Erectile Function; TRUS: Transrectal ulltrasound; GS: Gleason Score: DRE: Digital Rectal Examination; SD: Standard Deviation; IQR: Interquartile Range)

MRI Characteristics

MRI CHARACTERISTICS	**Overall**	**3D Group**	**Cognitive Group**	**p-value**
Number of lesion, mean (SD)	1.1 (±0.4)	1.1 (±0.3)	1.1 (±0.4)	1.0
Number of lesion	45	22	23	
Right lesion, number (%)	19 (42.2)	8 (36.4)	11 (47.8)	0.63
Left lesion, number (%)	22 (48.9)	14 (63.6)	8 (34.8)	0.10
Medial lesion, number (%)	4 (8.9)	0 (0.0)	4 (17.4)	0.12
Level of lesion, number (%)				
• Apical	3 (6.7)	0 (0.0)	3 (13.0)	0.24
• Apical-equatorial	14 (31.1)	14 (63.6)	0 (0.0)	< 0.01
• Equatorial	12 (26.7)	3 (13.6)	9 (39.2)	0.10
• Equatorial-basal	14 (31.1)	3 (13.6)	11 (47.8)	0.03
• Basal	1 (2.2)	1 (4.6)	0 (0.0)	0.97
• Apical-equatorial-basal	1 (2.2)	1 (4.6)	0 (0.0)	0.97
Location of the lesion, number (%)				
• Postero medial	10 (22.2)	1 (4.5)	9 (39.1)	0.01
• Postero lateral	29 (64.4)	17 (77.3)	12 (52.2)	0.14
• Anterior	1 (2.2)	1 (4.5)	0 (0.0)	0.99
• Anterolateral	3 (6.7)	1 (4.5)	2 (8.7)	0.97
• Transitional zone	2 (4.5)	2 (9.2)	0 (0)	0.44
PIRADS score, number (%)				
• PIRADS ≤ 3	8 (17.7)	4 (18.2)	4 (17.4)	0.74
• PIRADS >3	37 (82.3)	18 (81.8)	19 (82.6)	0.74
Prostate volume, mean (mL)	41.8 (±11.2)	47.9 (±19.7)	31.58 (±9.3)	< 0.01
Lesions volume, mean (CC)	4.3 (±2.3)	4.4 (±2.1)	4.1 (±2.4)	0.67
Extracapsular invasion, number (%)				
• ≤L2	12 (26.7)	5 (22.7)	7 (30.4)	0.80
• ≥L3	33 (73.3)	17 (77.3)	16 (69.6)	0.80
Seminal vesicles invasion, number (%)	5 (11.1)	3 (13.6)	2 (8.7)	0.72

TABLE 2: MRI Characteristics (PIRADS: Prostate Imaging– Reporting and Data System)

Intraoperative and perioperative variables

INTRAOPERATIVE PARAMETERS	**Overall**	**3D Group**	**Cognitive Group**	**p-value**
Operative time, mean (SD), min	128.5 (±37.7)	140.0 (±43.6)	117.5 (±42.1)	0.10
Blood loss, mean (SD), mL	232.0 (±53.1)	240.0 (±51.6)	230 (±54.2)	0.55
Full NS, number (%)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Partial NS, number (%)	24 (60)	17 (85)	7 (35.0)	< 0.01
Minimal NS, number (%)	16 (40)	3 (15)	13 (65.0)	< 0.01
Lymphadenectomy, number (%)	40 (100)	20 (100)	20 (100)	NA
Lenght of stay, median (IQR), days	5.4 (±1.3)	5.3 (±1.8)	5.6 (±2.0)	0.62
Catheterization time, median (IQR), days	4.6 (±1.2)	4.7 (±1.6)	4.5 (±1.9)	0.72
Postoperative complication, number (%)				
• Clavien < 3	3 (7.5)	1 (5.0)	2 (10.0)	1.0
• Clavien ≥3	1 (2.5)	1 (5.0)	0 (0.0)	1.0
Continence recovery, number (%)				
• Removal	22 (55.0)	12 (60.0)	10 (50)	0.75
• 1 month	35 (87.5)	18 (90.0)	17 (85)	1.0

TABLE 3: Intraoperative variables (NS: Nerve Sparing; DRE: Digital Rectal Exploration; SD: Standard Deviation; IQR: Interquartile Range)

Pathological variables

PATHOLOGIC FINDINGS	**Overall**	**3D Group**	**Cognitive Group**	**p-value**
Positive surgical margins, number (%)				
• Overall, number (%)	12 (30.0)	5 (25.0)	7 (35)	0.73
• Apex positive margins, number (%)	2 (5.0)	2 (10.0)	0 (0.0)	0.46
• pT2 positive margins, number (%)	0 (0.0)	0 (0.0)	0 (0)	NA
Prostate volume, mean (SD), mL	36.7 (15.0)	43.8 (±20.4)	26.58 (±9.2)	< 0.01
Tumor volume, mean (SD), mL	5.1 (1.9)	3.9 (±2.1)	3.35 (±1.9)	0.34
% tumor, mean (SD)	16.1 (13.7)	12.6 (±9.0)	13.7 (8.7)	0.69
Pathological stage, number (%)				
• pT2	9 (22.5)	4 (20.0)	5 (25)	1.0
• pT3	31 (77.5)	16 (80.0)	15 (75.0)	1.0
Pathological GS, number (%)				
• Not assessed (HT)	0 (0.0)	0 (0.0)	0 (0.0)	NA
• 2-6	0 (0.0)	0 (0.0)	0 (0.0)	NA
• 7	24 (60)	11 (55.0)	13 (65.0)	0.74
• 8-10	16 (40)	9 (45.0)	7 (35.0)	0.74
Extracapsular invasion, number (%)				
• ≤L2	11 (24.4)	5 (22.7)	6 (26.1)	0.90
• ≥L3	34 (75.6)	17 (77.3)	17 (73.9)	0.90

TABLE 4: Histopathological data (GS: Gleason Score; SD: Standard Deviation; IQR: Interquartile Range)

FIGURES LEGEND:

1. Figure 1 - Bend deformer using global Y axis as deformation main axis, along two different directions.
2. Figure 2 - Stretch deformer using global Y as the deformation axis.
3. Figure 3 – in case of posterior or antero-lateral lesion the model was mainly stretched and minimally bended
4. Figure 4 – in case of posterior or postero-lateral lesion the model was stretched and mainly bended from back to front
5. Figure 5 – the CI location resulted clearly visible on the surface of the opaque 3D virtual prostate model, irrespectively from its location; then, the suspicious area of CI was marked on the prostate capsule with a metallic clip
6. Figure 6 – the histopathological analysis confirmed the presence of suspicious tumour and CI at macroscopic and microscopic assessment in all the cases of 3D AR Group and in 86,9% and 47.0% of 2D Cognitive Group respectively