Impact of prostatic shape on the difficulty of robot-assisted laparoscopic radical prostatectomy

Ken Kamisawa
Keio University School of Medicine
Kazuhiro Matsumoto
kazz_matsumoto@yahoo.co.jp
Keio University School of Medicine
Toshikazu Takeda
Keio University School of Medicine
Kimiharu Takamatsu
Keio University School of Medicine
Naoya Niwa
Keio University School of Medicine
Yota Yasumizu
Keio University School of Medicine
Nobuyuki Tanaka
Keio University School of Medicine
Shinya Morita
Keio University School of Medicine
Takeo Kosaka
Keio University School of Medicine
Ryuichi Mizuno
Keio University School of Medicine
Hiroshi Asanuma
Keio University School of Medicine
Mototsugu Oya
Keio University School of Medicine

Research Article

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Abstract

Background

To investigate the impact of prostatic shape observed on preoperative magnetic resonance imaging (MRI) on the difficulty of robot-assisted laparoscopic radical prostatectomy (RALP).

Methods

We retrospectively reviewed the operative records of 211 patients who underwent RALP. We excluded patients who received neoadjuvant therapy. All surgeries in this study were performed by two surgeons. Each patient clinicopathological and surgical data were reviewed. Prostate sphericity was evaluated by measuring the roundness of the prostate at the largest axial slice by MRI. The console time was adopted as an objective indicator for assessing surgical difficulty.

Results

The mean prostate volume was 34 cc (range 14 to 88) and the mean prostate roundness was 0.55 (range 0.24 to 0.90). The mean console time was 194 minutes (range 95 to 296). To assess the relationship between prostate volume and console time, scatter plot analysis was performed. The prostate volume had a weak positive correlation with the console time ($r = 0.165$, $p = 0.016$). Similarly, scatter plot analysis between the prostate roundness and console time demonstrated a weak positive correlation ($r = 0.167$, $p = 0.015$) . Next, we performed subgroup analysis of 56 patients with a large prostate volume ($\geq$ 40 cc), and the positive correlation between the prostate volume and the console time disappeared ($r = 0.142$, $p = 0.296$). On the other hand, the prostate roundness was more strongly correlated with the console time ($r = 0.439$, $p = 0.001$).

Conclusions

Our results indicated that the spherical shape of the prostate is associated with the surgical difficulty of RALP, especially in patients with a large prostate volume.

Background

Since the introduction of robot-assisted laparoscopic radical prostatectomy (RALP), the number of prostatectomies has markedly increased. RALP is a valuable treatment option for clinically localized prostate cancer as its functional and oncological outcomes are as good as those by open or laparoscopic techniques [1, 2]. However, RALP for larger prostates is reported to be associated with greater blood loss and longer operative times [3–9]. RALP for large prostates is considered to be challenging and not suitable for novice surgeons. However, easy cases involving a large prostate and difficult cases involving a comparatively small prostate have been reported in clinical practice.

Previous several studies reported factors related to the prolongation of surgery, reflecting the difficulty. For example, a large prostate volume, protruding middle lobe, high Gleason score, high body mass index, extended lymph node dissection, and black race were reported to prolong the RALP surgery time [3–11]. However, to our knowledge, there are few reports on the relationship between prostatic shape and surgical time. Preoperative assessment of the factors that predict surgical difficulty is important for the preparation of surgery to ensure operative safety and favorable surgical outcomes [12–14]. It may also help to select suitable cases of RALP for novice urologists during the learning phase. Therefore, in this study, we analyzed the impact of prostatic shape on the surgical difficulty. We hypothesized that RALP for spherical prostates is more challenging than that for non-spherical prostates.

Materials And Methods

We reviewed the operative records of 211 patients who underwent RALP with the daVinci Xi Surgical System between January 2017 and August 2019 at Keio University Hospital. All procedures were performed by two surgeons, each of whom had performed more than 50 RALP procedures by 2017. No patient had obvious metastatic findings, previous neoadjuvant therapy, or pelvic radiation.

All procedures were carried out using the transperitoneal, six-port technique [15]. Briefly, the retropubic space of Retzius was released by incising the anterior peritoneum. The endopelvic fascia was opened from cranial to caudal bilaterally. Following bladder neck dissection, cutting of the vasa deferentia, and mobilization of the seminal vesicles, the bilateral prostatic pedicles were excised using Hem-o-Lock clips. Division of the dorsal venous complex (DVC) was performed using cold scissors and a 3–0 monocryl running suture was then used to ligate the open DVC. After cutting the urethra, posterior suspension was performed using 3 – 0 V-Loc, and anastomosis of the bladder neck and urethra was performed with a continuous running suture using two 20-cm 3 – 0 monocryl sutures tied together. We started the posterior anastomosis at the 5 o'clock and continued up to 10 o'clock. The second arm of the suture run up the anterior aspect and we tied both sutures at the 10 o'clock position. A 15-Fr JP drain was placed around the anastomosis. All procedures were performed safely without open conversion or serious complications.

After institutional review board approval, patient data were reviewed retrospectively. The console time was defined as the time from docking to undocking of the robot and was adopted as an objective indicator for assessing surgical difficulty. The following data were collected and assessed for the study: age, preoperative concentration of prostate specific antigen (PSA), Gleason grade group, prostate volume, prostate sphericity, nerve-sparing procedure, and extent of lymphadenectomy. The prostate volume was calculated using the following formula based on magnetic resonance imaging (MRI) findings: (π x height x width x length) / 6. Prostate sphericity was evaluated by measuring the roundness of the prostate at the largest axial slice by MRI, which is defined as a ratio of the radii of the inscribed circle and circumcircle that share the same center (Fig. 1).

To compare the two groups, we used the one-way analysis of variance with the Turkey correction for multiple comparisons. Categorical variables were analyzed by the Chi-square test. Pearson's product moment correlation coefficient was used to evaluate the strength of the linear relationship between the two variables. All reported p-values are two-sided and statistical significance was set at 0.05. Statistical analysis was performed using SPSS version 25.0 (IBM, Armonk, NY).

Results

The characteristics of all patients and the differences according to prostate size are summarized in Table 1. The mean patient age was 66 years old (range 45 to 77) and the mean preoperative serum PSA level was 9.5 ng/mL (range 3.6 to 40.0). Gleason grade group 1 was observed in 13 (6%) patients, group 2 in 65 (31%), group 3 in 57 (27%), group 4 in 51 (24%), and group 5 in 25 patients (12%). The mean prostate volume was 34 cc (range 14 to 88) and the mean prostate roundness was 0.55 (range 0.24 to 0.90). Eleven (5%) and 46 (22%) patients underwent bilateral and unilateral nerve-sparing procedures, respectively. The extent of lymphadenectomy was "limited" in 98 (46%) patients and "standard" in 90 (43%) patients. The other 23 (11%) patients did not receive lymphadenectomy. The mean console time was 194 minutes (range 95 to 296). Patients with a large prostate ($\geq$ 40 cc) had a slightly longer console time ($p < 0.001$) and higher roundness ($p < 0.001$).

Table 1
The clinicopathological characteristics of all patients, and differences according to the prostate size and console time

	Entire cohort	Prostate volume <40 cc	Prostate volume ≥ 40 cc	P-value	Console time ≤ 194 min	Console time >194 min	P-value
Number of patients	211	155	56		113	98	
Age (years)	66 [45, 77]	66 [45, 76]	67 [54, 77]	0.303	66 [45, 77]	66 [51, 77]	0.902
PSA (ng/ml)	9.5 [3.6, 40.0]	8.4 [3.6, 40.0]	12.5 [3.7, 36.0]	<0.001	8.6 [3.6, 36.0]	10.5 [3.7, 40.0]	0.031
Gleason grade group				0.199			0.401
1	13 (6%)	6 (4%)	7 (13%)		6 (5%)	7 (7%)	
2	65 (31%)	47 (30%)	18 (32%)		38 (34%)	27 (28%)	
3	57 (27%)	45 (29%)	12 (21%)		34 (30%)	23 (23%)	
4	51 (24%)	38 (25%)	13 (23%)		25 (22%)	26 (27%)	
5	25 (12%)	19 (12%)	6 (11%)		10 (9%)	15 (15%)	
Prostate volume (cc)	34 [14, 88]				31 [14, 65]	38 [19, 88]	<0.001
Roundness	0.55 [0.24, 0.90]	0.54 [0.24, 0.90]	0.60 [0.37, 0.80]	<0.001	0.54 [0.27, 0.90]	0.58 [0.24, 0.81]	0.009
Console time (min)	194 [95, 296]	190 [95, 296]	206 [113, 296]	<0.001			
Nerve sparing				0.307			0.824
none	154 (73%)	116 (75%)	38 (68%)		84 (74%)	70 (71%)	
unilateral	46 (22%)	33 (21%)	13 (23%)		24 (21%)	22 (23%)	
bilateral	11 (5%)	6 (4%)	5 (9%)		5 (5%)	6 (6%)	

Means and ranges are provided for continuously coded variables.

Lymphadenectomy				0.305			0.819
none	23 (11%)	16 (10%)	7 (12%)		11 (10%)	12 (12%)	
limited	98 (46%)	68 (44%)	30 (54%)		54 (48%)	44 (45%)	
standard	90 (43%)	71 (46%)	19 (34%)		48 (42%)	42 (43%)	

Means and ranges are provided for continuously coded variables.

We first divided patients into two groups according to the mean console time as follows: ≤ 194 min (n = 113) and > 194 min (n = 98) (Table 1). We did not find a significant difference between the two groups regarding patient age ($p = 0.902$), Gleason grade group ($p = 0.401$), the nerve-sparing procedure ($p = 0.824$), or extent of lymphadenectomy ($p = 0.819$). On the other hand, PSA ($p = 0.031$), prostate volume ($p < 0.001$), and prostate roundness ($p = 0.009$) were associated with longer console times. To assess the relationship between prostate volume and console time, scatter plot analysis was performed. The prostate volume had a weak positive correlation with the console time ($r = 0.165$, $p = 0.016$) (Fig. 2a). Similarly, scatter plot analysis between the prostate roundness and console time demonstrated a weak positive correlation ($r = 0.167$, $p = 0.015$) (Fig. 2b). Next, we performed subgroup analysis of 56 patients with a large prostate volume (≥ 40 cc), and the positive correlation between the prostate volume and the console time disappeared ($r = 0.142$, $p = 0.296$) (Fig. 3a). On the other hand, the prostate roundness was more strongly correlated with the console time ($r = 0.439$, $p = 0.001$) (Fig. 3b).

Discussion

Accurately predicting and managing the surgical duration is important in reducing perioperative complications and hospital costs [12–14]. Although some factors associated with prolonged operative time during RALP have been reported, no study has evaluated the relationship between prostate shape and surgical duration. To the best of our knowledge, this is the first report to demonstrate that the shape of the prostate affects the difficulty of RALP.

"Roundness" was used as an index to evaluate the roundness of the prostate in this study. Roundness is the measure of how close the shape of an object approaches a mathematical circle, which is calculated by a ratio of the radii of the inscribed circle and circumcircle that share the same center. We evaluated prostate sphericity by measuring the roundness of the prostate at the largest axial slice by MRI (Fig. 1). The console time was adopted as an objective indicator for assessing surgical difficulty. A scatter plot was created to assess the relationship between console time and roundness. In the whole cohort analysis, the console time increased with increased roundness. Furthermore, in subgroup analysis of patients with a large prostate volume (≥ 40 cc), prostate roundness was strongly correlated with the console time. Our results indicated that RALP for large and spherical prostates requires advanced surgical techniques. RALP is now widely employed and young urologists are expected to perform more RALP procedures in the future. This study may help in selecting cases for a novice surgeon.

The following are possible reasons why surgery for a spherical prostate is difficult: (1) When the bladder neck is divided, it is difficult to imagine the anatomical boundary three-dimensionally because the cross-section is not flat (Fig. 4a). (2) When dividing the lateral pedicle, protrusion of a spherical prostate to the posterior side shortens the distance of the pedicle (Fig. 4b). (3) Lastly, when treating the apex side of the prostate, the space between the apex and endopelvic fascia and/or pubic bone is narrowed (Fig. 4c).

A strength of our study is that assessing the difficulty of surgery based on roundness is clinically practical because it is simple and does not require additional costs. Most patients undergoing radical prostatectomy inevitably undergo preoperative MRI. It is simple to draw the inscribed and circumscribed circles of the prostate on MRI, and measure the radius of each. However, this study has some limitations. Our results were based on two surgeons at a single institution, which may have limited the validity of our findings. Each performed more than 50 RALP procedures by the starting point of this study, but favorable operative outcomes were reported to be achievable after a longer learning period [16]. No patients in our study cohort received "extended" lymphadenectomy, which is recommended in cases with an estimated risk of node positive > 5% [17]. Therefore, the difference in the skills of the surgeons and operative procedures may affect the operation time and the impact of prostate shape. In addition, the shape of the prostate was evaluated using single MR images. Evaluation of prostatic sphericity may be more accurate by adding MR images of coronary and sagittal sections.

In conclusion, roundness was significantly correlated with console time. The spherical shape of the prostate affects the difficulty of RALP, especially in patients with a large prostate volume. Thus, measuring the roundness of the prostate before surgery can lead to better estimates of the operative time, which may help determine the risk status of patients or identify cases appropriate for novice urologists.

Abbreviations

DVC
dorsal venous complex
MRI
magnetic resonance imaging
PSA
prostate-specific antigen
RALP
robot-assisted laparoscopic radical prostatectomy

Declarations

Ethics approval and consent to participate

All procedures performed in the study involving the human participants were in accordance with relevant guidelines and regulations, and with the 1964 Helsinki declaration and its later amendments. This retrospective study was approved by the Ethics Committee of Keio University Hospital, and was performed in accordance with IRB #20160084 protocol. The Ethics Committee of Keio University Hospital waived the requirement for informed consent because of the retrospective nature of this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

KK, KM and KT conceived and performed studies, wrote the manuscript. KK prepared figure 1-3, and KM prepared figure 4. KK, KM, and TT collected data. KM, TT, NN, YY, NT, SM, TK, RM, HA and MO provided expertise and feedback. All authors reviewed the manuscript. All authors approved the manuscript to be published, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Figures

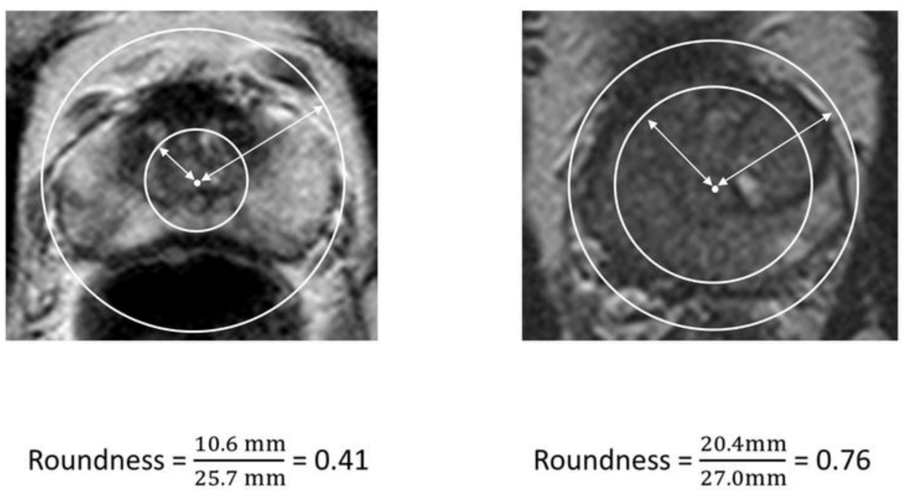

Figure 1

Prostate sphericity was evaluated by measuring the roundness of the prostate at the largest axial slice by MRI, which is defined as a ratio of the radii of the inscribed circle and circumcircle that share the same center.

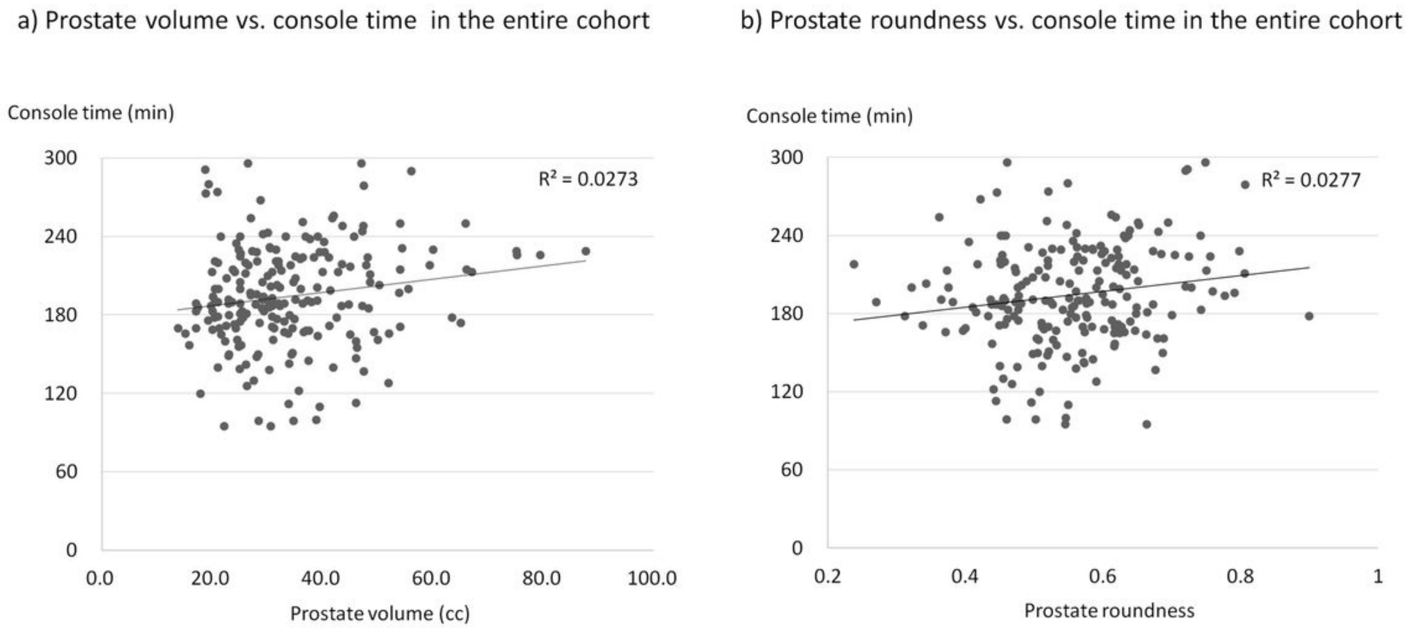

Figure 2

a) Scatter plot analysis demonstrated a weak positive correlation between the prostate volume and the console time (r = 0.165, p = 0.016). b) Similarly, a weak positive correlation was observed between the prostate roundness and the console time (r =0.167, p=0.015).

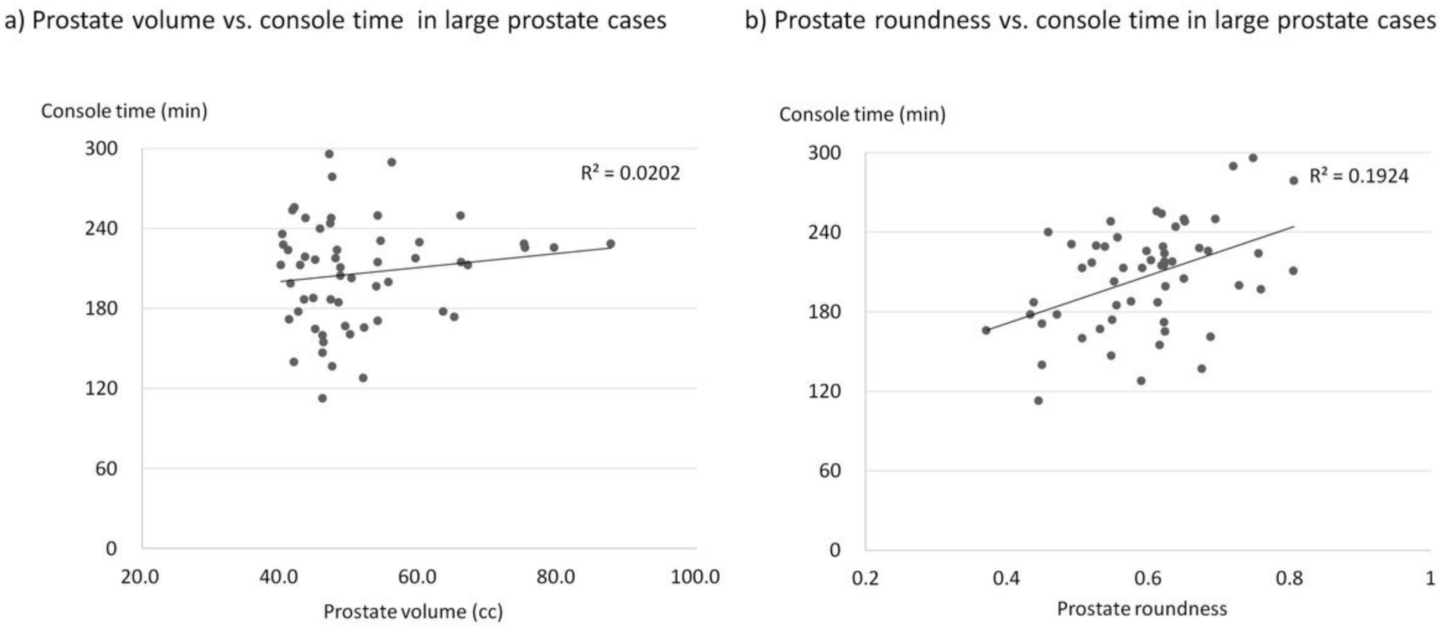

Figure 3

a) On subgroup analysis of 56 patients with a large prostate volume (≥ 40 cc), the positive correlation between the prostate volume and the console time disappeared (r = 0.142, p = 0.296). b) However, prostate roundness was more strongly correlated with the console time (r =0.439, p=0.001).

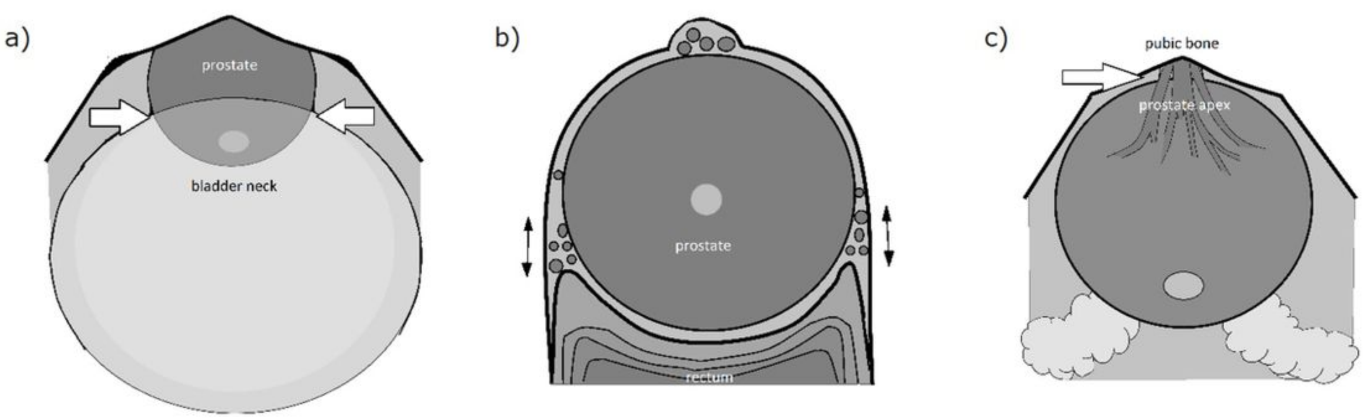

Figure 4

a) When the bladder neck is divided, a spherical prostate pushes the bladder neck cranially and makes it difficult to imagine the anatomical boundary three-dimensionally because the cross-section is not flat. b) When dividing the lateral pedicle, protrusion of the spherical prostate to the posterior shortens the distance of the pedicle and may become an obstacle during excision. c) The narrow space between the apex of a spherical prostate and the endopelvic fascia and/or pubic bone hinders preservation of the puboperinealis muscle, division of the DVC, suturing the open DVC, and cutting the urethra.