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INTEGRATED STUDY MASTER'S THESIS

Robot-Assisted Laparoscopic Prostate and Kidney Surgical Techniques Using Versius Surgical Robotic System

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List of Abbreviations

3D	Three-dimensional
BMG	Bipolar Maryland grasper
BMI	Body mass index
BPLND	Bilateral pelvic lymph node dissection
BSU	Bedside unit
CA	Comparative analysis
CE	European conformity marking
CMR	Cambridge Medical Robotics Ltd.
CR	Case report
CS	Case series
EBL	Estimated blood loss
eRARP	extraperitoneal robot-assisted radical prostatectomy
FG	Fenestrated grasper
HLND	Hilar lymph node dissection
Hybrid	Mixed laparoscopic and robotic surgery
IDEAL	Idea, Development, Exploration, Assessment, Long-term monitoring
IQR	Interquartile range
ISUP	International Society of Urological Pathology
LD	Lateral decubitus
LPN	Laparoscopic pyelonephritis
MCCS	Multicenter case series
MCS	Monopolar curved scissors
MIS	Minimal invasive surgery
Mo	Months
MRI	Magnetic resonance imaging
N/A	Not applicable

PADUA	Preoperative Aspects and Dimensions Used for an Anatomical Classification of Renal Tumous
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PS	Prospective Study
PSA	Prostate-specific antigen
PSM	Positive surgical margin
RALP	Robot-assisted laparoscopic prostatectomy
RAPN	Robot-assisted partial nephrectomy
RARN	Robot-assisted radical nephrectomy
RARP	Robot-assisted radical prostatectomy
RAS	Robotic-assisted surgery
RASN	Robot-assisted simple nephrectomy
RASP	Robot-assisted simple prostatectomy
RCS	Retrospective case series
REBA	Rapid entire body assessment
ROS	Retrospective observational study
RP	Retroperitoneal
TDB	Trendelenburg
TNM	Tumor, node, metastasis
TP	Transperitoneal
TRUS	Transrectal ultrasound
UKCA	United Kingdom conformity assessment
Versius	Versius Surgical Robotic System

Summary

Minimally invasive surgery (MIS) has transformed urologic practice by reducing patient morbidity and accelerating recovery, still traditional laparoscopy remains challenging due to limited dexterity and ergonomics. The Versius Surgical Robotic System (Versius), comprising modular bedside units and an open console with 7 degrees of freedom instrumentation, is designed to address these limitations through enhanced flexibility, surgeon ergonomics and reduced surgical footprint.

This systematic literature review, conducted from November 2023 to March 2025 evaluates the early experiences with the Versius in robot-assisted radical (RARP), and simple prostatectomy (RASP), as well as radical (RARN), partial (RAPN), and simple nephrectomy (RASN) presented in 16 clinical studies (10 prostate, 5 kidney, 1 mixed). Data extraction focused on patient demographics and Versius set-up (bedside unit configuration; port placement and surgical approach), key efficiency metrics (set-up, console and total surgery times; conversion rates; estimated blood loss; inpatient stay; complications), and oncological (TNM staging, Gleason or PADUA scores, positive surgical margins; lymph node status) and functional outcomes (PSA levels, urinary continence).

Overall, Versius proved feasible and safe in all urological procedures, with low conversion rates (<8%), median estimated blood loss between 100-200 mL, and predominantly Clavien-Dindo grade I-II complications. Prostate series have reported rapid learning curves - with console times stabilizing around 100 minutes after the first cases - and continence rates exceeding 90% at one year. Renal studies demonstrated comparable operative times to established platforms, with positive margin rates of less than 10% for partial nephrectomies. Technical advantages included customizable bedside unit (BSU) placement, open surgeon console for improved communication, and ergonomically designed console with ability for seated or standing position and fully wristed 5mm instruments; limitations included instrument reach in high BMI patients, initial docking complexity and clinically insignificant system alarms delaying surgery.

These results support the integration of Versius into urologic practice, although larger, prospective, multicenter studies and long-term follow-up are warranted to validate oncologic equivalence, refine cost-effectiveness analyses, and optimize set-up standardisation.

Keywords

Versius Surgical Robotic System

Robot-assisted surgery

Radical prostatectomy

Partial nephrectomy

Learning curve

Minimally invasive surgery

Urology

CMR

Chapter 1: Introduction

1.1 BACKGROUND

1.1.1 Minimally Invasive Surgery and Its Limitations

In the surgical field, advances in recent years have evolved around establishing techniques that are less invasive, reduce patients' recovery time and generate better outcomes than conventional open surgeries (1,2). This led to the development of minimally invasive surgery (MIS) via laparoscopic access which has become the standard of care, surpassing traditional open surgery due to its advantages, including reduced operative time, fewer complications, diminished postoperative pain, minimal blood loss, and faster patient recovery (2–4).

However, laparoscopic surgery faces significant challenges due to inherent limitations, such as restricted instrument manoeuvrability, missing haptic feedback, two-dimensional (2D) visualization, and the lack of ergonomically optimized surgical tools. These challenges render the technique both technically complex and physically taxing for surgeons, contributing to a prolonged and steep learning curve (2–5). Especially in prostate and kidney surgery, these issues become problematic when trying to reach confined anatomical spaces such as the retroperitoneum in partial or total nephrectomy and the pelvis in radical prostatectomy (1–3,6).

1.1.2 Emergence of Robot-Assisted Surgery

The limitations of traditional surgical approaches spurred the rise of robot-assisted surgery (RAS) in the late 1980s. The first prototype, PUMA 560, was developed by Dr. Yik San Kwoh to assist in stereotactic brain surgery, followed by PROBOT for transurethral prostate resection and ROBODOC for orthopaedic procedures (7). In 1995, Frederick H. Moll and Robert Younge founded Intuitive Surgical, introducing the first da Vinci system into clinical trials by 1998, with FDA approval in 2000 (7–9).

Over two decades, the da Vinci system has evolved into its fourth generation, featuring four robotic arms, a closed surgeon console, three-dimensional (3D) high-definition vision, specialized instruments, dual-console capability, and Firefly fluorescence

imaging (7,9). These innovations have transformed MIS by enabling precise dissection and suturing in confined spaces, improving dexterity, extending instrument reach, and reducing surgeon strain and physical tremor (1,2,6,10). As a result, patients experience fewer complications, less tissue trauma, reduced bleeding, and faster recovery times, leading to better overall outcomes (3,6,8,10–13).

1.2 CONTEXT

Robotic surgery now accounts for over 3% of surgeries worldwide, with over 6,500 daVinci units installed in 67 countries with growing acceptance replacing initial scepticism (12,13). While it has proven to be an efficient and safe MIS technique, further research is needed to evaluate its long-term benefits (2,6,8,14).

The most significant criticisms of robotic surgery to date have focused on high installation and maintenance costs, technological complexity requiring specialized training, stringent regulatory barriers, and substantial operating footprints (1,2,4,6,10,15–17). A pivotal shift occurred with the expiration of Da Vinci's patents, which opened the field to new surgical platforms designed to address these challenges and offer more efficient alternatives (10,12,18,19).

Cambridge Medical Robotics Ltd. (CMR) embraced this opportunity by developing the Versius Surgical Robotic System (Versius), which received the European CE Mark in March 2019 (4,7,10,19). Unlike Intuitive's well-established daVinci system, CMR prioritized mobility, flexibility, and surgeon feedback in optimizing Versius (3,20). Luke Hares, the concept's founder, refined the prototype through iterative studies focusing on components such as the arms, instruments, handgrips, and console. Input from surgeons and operating teams shaped each phase of development, resulting in a system distinct from Da Vinci (3,20).

Initial preclinical evaluations supported the feasibility and safety of Versius in performing complex urological procedures. In a cadaveric study by Vasdev et al. (2023), robot-assisted prostatectomies were successfully completed using both 3-arm and 4-arm bedside unit configurations, with minor modifications to port and unit positioning based on surgeon preference. Instrument limitations identified during the procedures were addressed through iterative design refinements (5). Similarly, Thomas et al. (2021) conducted 24 cadaveric renal and prostate procedures, all of which were successfully completed, with positive assessments of surgical access

and reach. The study also included live porcine nephrectomies, which were completed without complications, further supporting the system's safety and operability (3). Both studies followed the Idea, Development, Exploration, Assessment, Long-term monitoring (IDEAL) framework, providing early validation of Versius for clinical application in urology (3,5).

The Versius surgical robotic system features compact robotic arms mounted on independently mobile bedside units (BSU) measuring 38 x 38 cm, and an open console that supports seamless communication between the surgeon and the surgical team (3–5,21). The console is designed for use in either a seated or standing position and replaces traditional foot pedals with game controller-style handgrips. Equipped with 7 degrees of freedom, 3D imaging, surgeon-controlled haptic feedback, and a small operational footprint, Versius is particularly well-suited for urological procedures, including prostate and kidney surgeries (3,4,10,14,16,18,20–22).

Currently, Versius appears to be the second most widely adopted soft tissue robotic system with more than 140 platforms initiated globally, and has been used in over 30,000 procedures across multiple specialties, including urology, general surgery, gynecology, and thoracic surgery (13,23). Its versatility and modular design have led to its deployment in more than 70% of hospitals across two or more specialties (23). In 2023, CMR Surgical introduced key enhancements to the system, including vLimeLite, an integrated fluorescence imaging technology that enables real-time visualization of blood flow, tissue perfusion, and biliary anatomy, and the Ultrasonic Dissector, designed to improve dissection precision in minimally invasive procedures (23–25). Both features, along with the Versius Clinical Insights platform, have received European conformity (CE) and United Kingdom conformity assessment (UKCA) certification, supporting their clinical use in the UK and Europe and contributing to the system's expanding adoption (23,24).

1.3 SCOPE OF THE LITERATURE REVIEW

This literature review explores the application of the Versius robotic surgical system in robot-assisted prostate and kidney surgery, with a focus on prostatectomy and nephrectomy procedures. In the context of prostate surgery, the review examines robot-assisted radical prostatectomy (RARP) – with or without bilateral pelvic lymph node dissection (BPLND) – as well as robot-assisted simple prostatectomy (RASP).

For renal surgery, the review includes robot-assisted radical (RARN), partial (RAPN), and simple nephrectomy (RASN).

RAP is most indicated for localized or locally advanced prostate cancer, aiming for complete tumor removal while preserving adjacent structures (26). Success is evaluated through oncological (e.g., surgical margin status, lymph node involvement, tumor, node, metastasis (TNM) staging, Gleason score, and prostate-specific antigen (PSA) levels), functional (urinary continence and erectile function), and surgical outcomes (e.g., blood loss, conversion and complication rates, and inpatient stay) (27–29). Additionally, efficiency metrics such as system set-up time, console time, and total surgery time, as well as system-related issues like alarms or malfunctions, are used to assess the surgical platform performance (9,10,12,13,15,17,19,21,30,31).

RAN are performed for both malignant (primarily renal cell carcinoma (RCC)) and benign renal conditions. The choice between partial, simple, or radical nephrectomy is determined by tumor characteristics, pathology, renal function, and patient comorbidities (32). Partial nephrectomy is preferred for small, peripheral tumors to preserve renal function; radical nephrectomy is indicated for larger or more aggressive lesions and may include hilar lymph node dissection (HLND); simple nephrectomy is reserved for non-functioning benign kidneys (32). As with prostatectomy, outcomes are assessed across oncological, functional, and surgical domains, including metrics such as surgical margin status, Preoperative Aspects and Dimensions Used for Anatomical (PADUA) score, TNM staging, and recurrence rates, as well as renal function preservation, intraoperative complications, and operative efficiency indicators (9,13,22,30,33,34).

1.4 PURPOSE & OBJECTIVES

This literature review aims to summarize the current body of evidence on the use of the Versius surgical robotic system in prostate and kidney surgery, focusing on early clinical experiences. It examines surgical techniques and set-up, including patient positioning, bedside unit configuration, trocar placement, port sizes, and surgical approach. Additionally, the review collects and compares available data on patient demographics such as age, body mass index (BMI), and gender. Adopting a clinically and surgically oriented perspective, it evaluates both efficiency metrics and patient-centered outcomes, including oncological results and recovery profiles.

The critical need for more effective and accessible robotic solutions in urological surgeries underscores the importance of evaluating both established and innovative robotic systems. This effort not only contributes to the ongoing evolution of robotic surgery but also supports its adoption in a broader range of healthcare environments, enhancing access and outcomes worldwide.

Chapter 2: Literature Search Strategy

Conducted over a span of 17 months (Nov 2023 – Mar 2025), this systematic literature review aims to capture and summarize the experiences with the Versius surgical robotic system in prostate and kidney surgeries so far.

An electronic literature search was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement of 2020 by Page et al. (2021) until March 30th, 2025 using the PubMed database (35). The search was carried out via free-text using the following keywords: "Robot-assisted prostatectomy" or "RARP", "Robot-assisted laparoscopic prostatectomy" or "RALP", "Robot-assisted nephrectomy" or "RARN", "Robot-assisted partial nephrectomy" or "RAPN" or "Robot-assisted surgery" and "Versius".

The following criteria for inclusion were utilized in the article selection process:

1. Written in English language.
2. Full articles.
3. Full text available.
4. Published from inception to the search date (30th March 2025).
5. Studies on humans.
6. Articles regarding the use of the Versius robotic system for robot-assisted prostate and/or kidney surgery.

Otherwise, the following criteria for exclusion were employed:

1. Literature-, systematic, scoping or narrative reviews.
2. Perspectives or communications.
3. Papers centred on surgery with the Versius robotic system devoid of urological procedures.
4. Preclinical studies on animals or cadavers.

The literature search yielded a total of 82 relevant records in the PubMed database. After exclusion of 28, 54 records were screened and 44 were excluded. After a full-

text assessment for the remaining 10 studies, no further studies were excluded. 7 studies were identified from reference lists and added. Therefore, 16 eligible studies in total were included in the systematic review, 10 of those for prostate, 5 for kidney surgery, and 1 for both.

Data was manually extracted for the following variables:

- First author's name, publication year and country
- Number of procedures in total and number and type of prostatectomies or nephrectomies investigated
- Patient demographics; Number of patients, age, gender, and BMI
- Technique, and set-up; Number and port sizes of bedside units (BSUs) and instruments used
- Key metrics of efficiency; Set-up, console and total surgery time, conversion rate, estimated blood loss (EBL), complications and inpatient stay
- Functional and oncological outcomes
    - For prostatectomies: PSA, prostate volume, TNM staging, Gleason score, surgical margin and lymph node pathology, urinary continence evaluation
    - For nephrectomies: TNM staging, Preoperative Aspects and Dimensions Used for an Anatomical (PADUA) Classification of Renal Tumors, lesion size, surgical margin and lymph node pathology

The collected data were analyzed, and quantitative variables were described as mean ± standard deviation (s.d.) and median (interquartile range (IQR)), while qualitative variables were described as count and percentage.

Chapter 3: Results in Prostate Surgery

3.1 PATIENTS & METHODS

The studies provide data on the exact procedures performed, the patient demographics, the surgical approach used and the robotic platform set-up, offering insights into the types of patients on whom the Versius robot was initially used.

3.1.1 Procedures

Most performed out of the reported procedures across these initial experiences in prostate surgery with the Versius robotic system was RARP, often performed with BPLND. Abdelhakim et al. studied 118 patients, with 95 undergoing RARP with BPLND and 23 undergoing RARP alone (10). Zafar et al. reported 3 RARP cases of which 2 were with BPLND (13). Abdelhakim and Abdelwahab reported on 30 RARP cases, with 25 RARPs with BPLND and Polom and Matuszewski documented 58 RARP cases (19,21). Rocco et al. (June 2023) presented 3 RARP cases, where each case was performed with a different robotic system (Versius, daVinci, and Hugo RAS) (15). Hussein et al. described 9 RASPs during a 106-procedure transition, Rocco et al. (Feb 2023) a single RARP case and Dibitetto et al. (June 2024) shared 53 extraperitoneal RARPs (eRARP), 18 of which included BPLND (12,30,31). Another study by Dibitetto et al. (Sep 2024) aimed at comparing Versius with daVinci and performed 106 eRARPs in total, 53 with daVinci, and 53 with Versius, of which 4 involved BPLND (36). De Maria et al. reported 18 RARPs, 5 with BPLND and Reeves et al. evaluated 4 RARPs in a 10-case IDEAL Stage 1/2a study (9,17).

3.1.2 Patient Demographics

The reported ages of patients generally ranged from approximately 50 to the early 70s, with mean and median ages typically falling in the mid-to-late 60s. However, there is some variability observed. Hussein et al. reported a median age of 42 years (range 26-56) for their patient cohort, which however applied to all their 106 procedures performed and of those only 9 (8.49%) patients underwent a RASP (30). Another study with a younger cohort (50.67 years ± 21.75 s.d.) was Zafar et al. though here the mean

age was recorded separately for each type of procedure and the 3 (2%) RASP cases (13).

BMI values were reported by eight of the ten selected studies of which five fell within the overweight to obese categories according to standard BMI classifications (BMI > 25 kg/m² is overweight, and BMI > 30 kg/m² is obese (37)): Abdelhakim et al.; Abdelhakim and Abdelwahab; Polom and Matuszewski; De Maria et al.; Reeves et al. (9,10,17,19,21).

3.1.3 Technique

Building on the established practices of laparoscopic and daVinci-assisted surgery, early experiences with the Versius robotic system leveraged those standard set-ups as a foundation. Most studies employed a Trendelenburg position for optimized access to the pelvic region, with various angles: 10° (12,36), 20° (21), 25° (31), 28° (17) and unspecified steep angle (10,19). Some modifications were made, such as slightly lowering the legs to enhance ergonomics, to improve access to the prostate, and align ports effectively (15,17,21).

The surgical approach for RARP with the Versius system also shows some variation: transperitoneal approach was used by 4 studies (10,17,19,21) and extraperitoneal (eRARP) by 2 (12,36) while the other five studies did not indicate the surgical approach applied.

3.1.4 Set-Up

Most studies reported using 3 or 4 BSUs for RARP with some variation in the trocar sizes of the endoscope, robotic arms, and the number and size of accessory ports used. Generally, one BSU carried the endoscope through a 10- or 12-mm trocar and the other 2-3 BSUs made up the robotic arms with port sizes typically 5-, 10- or 12-mm, along with one or two accessory ports of varying sizes placed for the assistant surgeon.

Port placements were generally spaced 9–12 cm apart, adjusted for patient BMI, anatomy, and height, with taller patients requiring caudal adjustments for optimal instrument manoeuvrability and to prevent clashes (12,17,21). Specific configurations, such as placing suction or clipper trocars on the right, were employed in Polom and Matuszewski to streamline procedural flow and over time, these set-ups were refined to improve ergonomics and reduce intraoperative delays (21,30).

3.2 KEY METRICS OF EFFICIENCY

Evaluating a new robotic system involves assessing efficiency metrics such as total surgery time, docking and console time, system malfunctions requiring BSU or instrument replacements, estimated blood loss (EBL), complication rates and length of inpatient stay.

3.2.1 Set-up, Console & Total Surgery Time

Regarding set-up, console and total surgery time, the shortest set-up time was reported by Zafar et al. with 7.33 min and the highest in Rocco et al. (Feb, 2023) with 30 min (13,31). In console time as well as in total surgery time, Dibitetto et al. (June 2024) were the fastest with console time 100 min (range 63-240) and total surgery time 130 min (range 80-230) while Reeves et al. reported the slowest times with a median console time of 272 min (range 195-377) and 335 min (range 258-440) for total surgery time (9,12). Abdelhakim and Abdelwahab reported the times for their first nine and last 21 cases separately, achieving medians of 10 for set-up, 130 min for console time and 153 min for total surgery time in their later cases (19). Reeves et al. (2022) reported the longest surgical time, with a median of 335 min (range 258–440), suggesting a steeper learning curve or more complex cases (9).

3.2.2 Conversion Rate

Most studies demonstrated a 0% conversion rate, including those by Abdelhakim et al., Zafar et al., and De Maria et al (10,13,17). The highest conversion rate occurred in Dibitetto et al. (June 2024), at 7.54%, where the first 4 cases were performed via a hybrid approach, reflecting the surgeon's learning procedure, performing especially challenging parts of the surgery with the well-known laparoscopic approach and all else robotically. All surgeries afterwards as well as the 53 eRARPs in Dibitetto et al. (Sep 2024) were performed fully robotically with no conversions required (12,36). Hussein et al. reported 6 (5.66%) conversions to open due to intra-abdominal adhesions (30). Similarly, Polom and Matuszewski needed to convert to open in a case of an inflamed bladder due to a preoperative Bacillus Calmette-Guérin therapy (21). Despite these exceptions, conversion rates were generally low.

3.2.3 Estimated Blood Loss

The lowest reported EBL occurred in the case study by Rocco et al. (June 2023), where the RARP case with Versius had an estimated loss of less than 100 mL (15). A study

with a much higher number of cases and a very low EBL was Dibitetto et al. (June 2024) where the reported median of 53 eRARPs was 100 mL (range 30-300) (12). Conversely, Polom and Matuszewski as well as Abdelhakim et al. reported the highest EBL, with a median of 437 mL (range 210–2050) and a mean of 307.46 mL ± 61.44 s.d., respectively (10,21). However, no specifics on the outliers were given.

3.2.4 Complications & Inpatient Stay

Complications during and/or after the surgery were recorded in Clavien-Dindo Classification Grades I-III and were generally low across studies (38). The most common Grade I complication was intraoperative blood transfusions, 12 (10.17%) cases in Abdelhakim et al., and 1 (3.3%) case in Abdelhakim and Abdelwahab, and De Maria et al. administrated analgesics in 14 (77.78%) cases (10,17,19). Grade II complications were very seldom with urinary tract infections requiring antibiotic treatment in 1 (5.56%) case in De Maria et al., 2 (3.77%) cases in Dibitetto et al. (June 2024) and 2 (3.45%) cases in Polom and Matuszewski with unspecified reasons (12,17,21).

In 4 studies a total of 11 Grade III complications were reported and seemed to correlate with a prolonged inpatient stay. Abdelhakim et al. disclosed one case (0.84%) of urethra-cutaneous fistula occurred which was repaired 6 months after initial surgery and one case (0.84%) where an intraperitoneal urine leakage was detected at catheter removal and managed via reinsertion of the catheter and ultrasound-guided drain placement. Here, mean hospital stay was still quite low with 2.16 days ± 0.867 s.d. (10). In Polom and Matuszewski study however, the median inpatient stay of 4.5 days (range 4–12) was due to one case suffering from a rectal fistula detected 7 days postop and repaired endoscopically (21). Dibitetto et al. (Sep 2024) recorded a median inpatient stay of 3 (2-6) days and 4 Grade III complications but omitted any specifics (36). Lastly, the study of De Maria et al. presented one case with bowel obstruction due to port-site herniation corrected through emergency surgery resulting in a median inpatient stay of 4 days (range 3.75; 3-13) (17). The shortest mean inpatient stay achieved Zafar et al. with 1.33 days ± 0.47 s.d. (13).

3.3 FUNCTIONAL & ONCOLOGICAL OUTCOMES

Patient outcomes across the 10 selected studies were represented in pre- and postoperative prostate-specific antigen (PSA) and prostate volume values, TNM-

staging, positive surgical margins (PSM) and lymph node pathology, and evaluation of bladder continence.

3.3.1 Prostate-Specific Antigen & Prostate Volume

PSA was collected pre- and postoperatively. The reported mean or median preoperative PSA levels show some variation across the studies. De Maria et al. (2023) reported a notably higher median PSA level (15 ng/mL) compared to others with no clear explanation detectable in the study (17). All other studies reported a median preoperative PSA level of at least 8 ng/mL less than De Maria et al. with Abdelhakim et al. and Polom and Matuszewski documenting 9 and 9.8 ng/mL, respectively, Dibitetto et al. (Sep. 2024) 7.8 ng/mL, Rocco et al. (June 2023) and Dibitetto et al. (June 2024) reporting 6 and 6.6 ng/mL, respectively, and Abdelhakim and Abdelwahab presenting 5.7 ng/mL (10,12,15,19,21,36). Remaining studies did not disclose their patients PSA levels.

The reported mean prostate volumes also varied and were only reported by half of the selected studies. Dibitetto et al. (June 2024) operated on the largest prostates with a mean volume of 58 (32-115) mL (12). Abdelhakim et al. and Polom and Matuszewski were relatively close again with 50 (20-167) mL and 48.5 (21-120) mL, respectively (10,21). Lastly the smallest prostates were recorded in the single Versius case by Rocco et al. (June 2023) with 40 mL which was however collected postoperatively on pathology report and by Abdelhakim and Abdelwahab with 33.13 (20-150) mL (15,19).

All studies that reported postoperative PSA levels showed high rates of undetectable or very low PSA, which is the expected outcome of successful radical prostatectomy. The time points at which PSA was measured varied across the studies from 1,5 to 6 months, making a direct comparison of the exact values difficult.

3.3.2 TNM Staging & Gleason Score

Of the ten studies reviewed, four reported TNM and Gleason staging in detail, with Abdelhakim et al. and Abdelhakim and Abdelwahab providing the most comprehensive pre- and postoperative data (10,19). In contrast, other studies reported these pathological outcomes less extensively, while Zafar et al. and Hussein et al. did not report TNM or Gleason staging information at all (13,30).

Preclinical imaging in Abdelhakim et al. indicated a range of cT1b (1 case, 0.8%) to cT3b (4 cases, 3.4%) in their 118 cases in total, the highest suspected occurrence was cT1c with 52 (44.1%) cases, closely followed by cT2a with 23 (19.5%) cases and cT2b with 21 (17.8) cases. Of all cases, 112 (94.9%) were cN0 and 6 (5.1%) were cN1 and none with metastasis. Pathology reports revealed that no case was lower than pT2a and the stage responsible for the highest number of cases was pT2c with 65 (55.1%). Regarding lymph node staging 23 (19.5%) cases were downgraded to pNx, 78 (66.1%) cases were pN0 and 17 (14.4%) were pN1. On Gleason stage, clinical evaluation in Abdelhakim et al. displayed a range from 6 (3+3) to 9 (4+5) where 7 (4+3) accounted for more than half of the cases (62 cases, 52.5%). Pathology then recorded 7 (3+5) for half of the cases (59, 50%) and one (0.8%) case up to 10 (5+5) (10).

In Abdelhakim and Abdelwahab's 30 cases ranged from cT1b (1, 3.3%) to cT3b (1, 3.3%) with the highest suspected occurrence in cT2b (10, 33.3%). 96.7% (29) were suspected to be cN0 and only 1 (3.3%) was suspected to be cN1. As in the previously described study (Abdelhakim et al.), pathology results did not show any case below pT2a which was also the most frequently detected stage with 12 (40%) cases, followed by pT2b in 10 (33.3&) patients pT2c in 6 (20%) patients, and pT3a and pT3b each in 1 (3.3%) patient. The lymph node pathology report showed insufficient material (pNx) in 5 (16.67%) patients, pN0 in 23 (76.67%) patients, and pN1 in 2 (6.6%) patients. Regarding Gleason score, this study showed a preoperative range from 6 (3+3) to 8 (4+4) with 7 (3+4) in 14 (46.7%) patients being the most common score and the postoperative results were as follows: 6 (3+3) in 4 (13.33%) patients, 7 (3+4) in 18 (60%) patients, 7 (4+3) in 6 (20%) patients, 8 (4+4) in 1 (3.3%) patient, and 9 (4+5) in 1 (3.3%) patient (19).

Polom and Matuszewski did not provide specific details on preoperative or postoperative TNM staging but noted that on preoperative magnetic resonance imaging (MRI) 25 (48%) of the patients were suspected to have extra-prostatic disease. On pathology report it were even 27 (46.5%) patients. The preoperative Gleason scores were converted from risk groups: ≤ 6 in 7 (12.06%) patients, 7 (3+4) - 7 (4+3) in 40 (68.96%) patients, and 8-10 in 11 (18.9%) patients. Postoperative Gleason scores were not provided (21).

The single case study by Rocco et al. (Feb 2023) was scored at Gleason 7 (3+4) pre- and postoperatively and staged at pT2c. The other case description by Rocco et al. from June 2023 had the exact same values (15,31).

De Maria et al.`s 18 cases ranged from cT1c (6, 33.3%) to cT2c (1, 5.6%) with the highest suspected occurrence in cT2a (10, 55.5%). Due to inclusion criteria N0 and M0, this applied to all 18 cases. On pathology, no case was lower than pT2c and half of the cases (9) were stage pT3a. Preoperative Gleason scores at transrectal biopsy were most often 7 (4+3) or (3+4) which was confirmed at final pathology report with the following constellation: 7 (3+4) in 10 (55.6%) patients, 7 (4+3) in 7 (38.9%) patients, and 9 (4+5) in 1 (5.5%) patient (17).

The distribution of TNM-stages in Dibitetto et al. (Sep 2024) was as follows: unpalpable (cT1) in 45 (85%) patients and palpable (cT2-cT3) in 8 (15%) patients. The clinical Gleason score was converted from International Society of Urological Pathology (ISUP) group and included 12 (25%) patients with 2-6, 13 (25%) patients with 7 (3+4), 14 (26%) patients with 7 (4+3), 12 (23%) patients with a score of 8 (4+4, 3+5, or 5+3), and one (2%) patient with 9-10. Pathology revealed pT2 in 38 (72%) patients, pT3a in 14 (26%), and pT3b in one (2%) patient. The pathological N stage was pNx in 49 (92%), pN0 and pN1 in 2 (4%) patients each (36).

The preoperative data of Dibitetto et al. (June 2024) notes exclusion criteria of TNM-stages ≥ T4 with no specific breakdown provided. Preoperative Gleason scores were converted from ISUP Grade and ranged from 2 to 10, but detailed or postoperative scores were not reported. Postoperatively, pT2c was noted in 8 (15%) patients who received adjuvant radiotherapy due to PSM, positive nodes and/or high-risk final ISUP (12).

The study by Reeves et al. did not explicitly state preoperative TNM data. However, Gleason scores at biopsy were converted from preoperative ISUP grade and were as follows: 7 (3+4) in 2 (50%) cases, 7 (4+3) in 1 (25%) case, and 9-10 in 1 (25%) case. Postoperatively, pT2 was found in all 4 (100%) patients (9).

3.3.3 Positive Surgical Margins & Lymph Node Pathology

The rates of PSM varied considerably across the studies, ranging from 0% to 83.3%. The study with the highest percentage of PSM was De Maria et al. with 15 (83.3%) cases and seemed to have no exact explanation other than the small sample size and

the high number of patients with extracapsular disease at definitive diagnosis (17). Perioperative, the surgeons negated any obstacles that could have explained the high PSM. Zafar et al. represents another study with a small cohort of 3 RARPs where the one case with PSM makes an overall 33.3%. Polom and Matuszewski 15 (25.8%) cases with PSM, Dibitetto et al. (Sep 2024) had 2 (4%), Dibitetto et al. (June 2024) found 8 (15.1%) and Abdelhakim and Abdelwahab 2 (6.67%) (12,13,19,21,36). Reeves et al., Rocco et al. (Feb 2023), Rocco et al. (June 2023) and Abdelhakim et al. reported 0% PSM for all their cases and Hussein et al. was the only study on RAP not to provide data on PSM (9,10,15,30,31).

3.3.4 Bladder Continence Evaluation

Seven of the selected studies provide information on the evaluation of full continence at various postoperative time points following RARP and though the definition of full continence can vary between studies, it generally refers to the absence of urinary leakage or the use of no pads or one security pad per day.

Abdelhakim et al. provided the most detailed longitudinal data, showing a gradual improvement in continence rates over 12 months at which time 107 (90.7%) of their patients had regained full continence (10). Other studies offered snapshots at earlier time points, generally indicating increasing rates of continence with longer follow-up. Some studies, particularly those focusing on initial experiences such as Polom and Matuszewski, Reeves et al and De Maria et al. or single cases, like Rocco et al (Feb 2023), had limited or no specific data on continence evaluation (9,17,21,31).

Chapter 4: Results in Kidney Surgery

4.1 PATIENTS & METHODS

The studies provide data on the exact procedures performed and primarily focus on RAPN, RASN, and RARN. Furthermore, patient demographics, the surgical technique and the robotic platform set-up are described.

4.1.1 Procedures

Zafar et al. reported the highest overall volume, with 150 procedures, including the greatest number of RASN (55, 36.7%) and RARN (36, 24%) cases (13). Meneghetti et al. performed 15 procedures, including the only reported cases of RAPN with hilar lymph node dissection (HLND) (2, 13.3%) and conversions to RARN (2, 13.3%) (22). Dal Moro et al. was a single case study of a retroperitoneal RASN and Abdelhakim and Abdelwahab conducted 30 RAPNs — the highest number of RAPNs (34,39).

in a single study (34). Hussein et al. carried out 106 procedures, including 42 (39.6%) RASN, 10 (9.4%) RARN, and 6 (5.7%) RAPN (30). Reeves et al. performed 10 procedures, including 2 RARN, 4 RARP — reported separately under results of prostate surgery — along with 3 pyeloplasties and 1 adrenalectomy, which were not included in this analysis (9).

4.1.2 Patient Demographics

Patient age across the five selected studies ranged widely, reflecting variable patient selection. The youngest cohort was presented in Hussein et al. with a median age of 35 (IQR 25-50) years for RASN, 56 (IQR 47-60) years for RARN and 45 (IQR 26-50) years for RAPN while Meneghetti et al. reported the highest median age with 64 (IQR 55-69) (22,30).

BMI data were reported in three studies. Zafar et al. showed lower BMIs for RASN patients (22.42 ± 4.43 kg/m²) compared to RARN patients (25.69 ± 4.28) (13). Reeves et al. had a mean BMI of 26 kg/m² for their 2 patients, Dal Moro et al. had 27 kg/m², and Abdelhakim and Abdelwahab reported the highest average BMI at 27.96 ± 3.71 kg/m² (9,34,39).

The proportion of male patients also varied across studies. Meneghetti et al. and Abdelhakim and Abdelwahab each reported 40% male participants (6 and 12 patients, respectively) (22,34). Hussein et al. reported 59.5% male patients for RASN, 60% for RARN, and 50% for RAPN (30). Zafar et al. and Reeves et al. did not report gender distribution (9,13).

4.1.3 Technique

For robot-assisted nephrectomies (RAN), surgeons across the five selected studies commonly utilized lateral decubitus positions adjusted based on the kidney's location: Meneghetti et al. reported using a 30° modified lateral decubitus position, while Abdelhakim and Abdelwahab, Dal Moro et al. and Hussein et al. used a standard lateral decubitus position (22,30,34,39). Zafar et al. and Reeves et al. did not specify patient positioning (9,13).

Regarding the surgical approach, Meneghetti et al. and Abdelhakim and Abdelwahab employed a transperitoneal approach, and as previously mentioned, the single case study by Dal Moro was performed through a retroperitoneal approach though it was not clearly stated in the other studies (22,34,39).

4.1.4 Set-Up

Across the studies that provided this information, the consistent use of 3 BSUs was noted. Only in Dal Moro et al. the set-up was changed intraoperatively to 4 BSUs (39). The port configuration usually included one endoscope port (around 10-12 mm), two robotic arm ports (typically 5 mm, but 10 mm in Abdelhakim and Abdelwahab), and one or more accessory ports with varying sizes (5, 10, 12, or 15 mm) depending on the study (34).

Port placement followed standard laparoscopic principles but was adjusted for kidney anatomy and patient factors such as BMI (22,30). Reeves et al. noted minor modifications to improve arm mobility and prevent instrument clashes in low-BMI patients (9).

This initial experience suggests a degree of standardization in the robotic platform setup for urological procedures, while also allowing for some flexibility in port placement and size.

4.2 KEY METRICS OF EFFICIENCY

Analyzing the surgical performance metrics of the five studies using the Versius robotic system in nephrectomies, reveals significant variability reflecting differences in institutional experience, case complexity, and procedural focus. Below, trends and extremes observed in key operative parameters are described.

4.2.1 Set-Up, Console & Total Surgery Time

Operative times for renal procedures performed with the Versius robot varied across the five selected studies, with notable differences observed between the three nephrectomy types: RASN, RARN, and RAPN.

For RASN, Zafar et al. reported relatively short operative times, with a mean set-up time of 9.8 ± 4.0 min, total surgery time of 143.5 ± 47.3 min, and console time of 86.8 ± 41.5 min (13). Hussein et al. reported similar total surgery duration (median 145 min IQR 115–170) and a longer set-up time (median 14 min), though their console time was higher at 110 min (IQR 93–127), suggesting slightly longer intraoperative engagement despite comparable overall times (30). Dal Moro et al. reported only set-up, and console time which were 16 and 110 min, respectively (39).

For RARN, Zafar et al. again reported shorter times, with a mean set-up time of 9.9 ± 5.0 min, total surgery time of 146 ± 45.9 min, and console time of 82.6 ± 29.4 min (13). In comparison, Hussein et al. reported a longer total surgery time (median 167 min, IQR 160–190) and the same median set-up time of 14 min, but did not provide console time data (30).

For RAPN, more variation was observed. Meneghetti et al. reported the shortest durations, with a median set-up time of 13 min (IQR 12–14), total surgery time of 105 min (range 100–110), and console time of 75 min (66–80) (22). Abdelhakim and Abdelwahab reported a shorter mean set-up time of 9.2 ± 0.9 min but significantly longer operative durations, with a mean total surgery time of 177.2 ± 29.5 min and console time of 149 ± 14.3 min — nearly double that of Meneghetti's cohort (34). However, Meneghetti's study noted that console time during RAPN can be significantly influenced by the preoperative surgical preparation, particularly depending on the complexity of the case and the method used to isolate the renal hilum (22). Hussein et al. reported a similarly high total surgery time (median 170 min, IQR

140–180) and a longer set-up time of 14 min but did not include console time data (30).

4.2.2 Conversion Rate

Conversion rates varied across studies and procedure types. Both Zafar et al. and Hussein et al. reported conversions for RASN and RARN, primarily due to intraabdominal adhesions (13,30). Zafar et al. documented three RASN-to-open conversions — two due to adhesions or an adherent colon, and one due to pleural injury — as well as one RARN conversion related to dense adhesions and large tumor size (13). Similarly, Hussein et al. reported two RASN and one RARN conversions, all attributed to severe adhesions (30). Meneghetti et al. and Abdelhakim and Abdelwahab, focusing primarily on RAPN, reported no conversions as well as Reeves et al. in their small series including RARN and Dal Moro in their one RASN case (9,22,34,39).

4.2.3 Estimated Blood Loss

EBL varied across studies, influenced by both procedure type and case mix. Zafar et al. reported lower mean EBL for RARN (57.83 ± 32.29 mL) compared to RASN (132.31 ± 320.52 mL), though the large standard deviation for RASN indicates a wide range of blood loss (13). Meneghetti et al. and Abdelhakim and Abdelwahab reported relatively low EBL for RAPN, with 200 mL (IQR 100-250) and 154.33 ± 67.19 mL, respectively (22,34). In contrast, Hussein et al. observed the highest EBL for RAPN, along with a wider range (450 mL, IQR 150-500), and reported a higher median EBL for RARN (200 mL, IQR 100-600) compared to RASN (100 mL, IQR 50–200) (30).

4.2.4 Complications & Inpatient Stay

Complication rates and hospital stay durations varied across studies and procedure types but were generally low.

Reeves et al. provided minimal information in their small RARN series of 2 RARN cases (9). Hussein et al. reported the highest rate of perioperative transfusions, classified as Grade II, affecting 14.3% of RASN, 40% of RARN, and 33.3% of RAPN cases. Their patients also had relatively long hospital stays, with a median of 4 days for RASN and 3 days for RARN, though RAPN length of stay was not reported (30). In contrast, Meneghetti et al. observed the longest hospital stay in RAPN cases

(median 4 days, IQR 3–4), although they only reported one minor (Grade I) complication with a fever requiring antibiotic therapy (22).

Abdelhakim and Abdelwahab observed transfusions in 13.3% of RAPN cases (Grade I) and reported one Grade III complication (3.3%) due to a urine leak requiring stenting. Their cohort had a shorter mean stay of 2.37 ± 0.49 days (34).

Zafar et al. reported the shortest inpatient stay (mean 1.75 ± 1.49 days for RASN) and a low overall complication rate, limited to Grade I and II events, including fever (0.7%), surgical site infections (4%), and urinary tract infections (3.3%). No Grade III or higher complications were reported (13). However, one postoperative death occurred in a high-risk patient with severe chronic liver disease and coagulopathy undergoing RASN for a non-functioning kidney. Although the surgery and immediate recovery were managed without major complications, the patient later deteriorated at home and died shortly after admission to a local hospital (13).

4.3 FUNCTIONAL & ONCOLOGICAL OUTCOMES

4.3.1 TNM Staging, PADUA Score & Lesion Size

Tumor complexity and staging were variably reported. PADUA scores were available in two studies: Meneghetti et al. reported a median score of 8 (range 7–9), while Abdelhakim and Abdelwahab reported a higher mean score of 9.5 (range 8–11) (22,34). Lesion sizes ranged from 2.1 cm (22) to 8 cm (34).

TNM staging was inconsistently reported. Meneghetti et al. documented clinical T-stages (cT1–cT2c) with N0/N1 and no metastasis but did not provide pathological staging (22). In contrast, Abdelhakim and Abdelwahab reported only pathological staging: 16.7% pT1a, 56.7% pT1b, and 26.7% pT2a. Histology showed 80% clear cell and 20% papillary RCC (34).

Reeves et al. included two RARN cases—one pT1b Grade 2 clear cell RCC and one benign non-functioning kidney—while Zafar et al. and Dal Moro et al. did not report PADUA scores or TNM staging (9,13,39).

4.3.2 Positive Surgical Margins & Lymph Node Pathology

Postoperative pathology revealed one case of positive surgical margins (6.67%) in the cohort reported by Meneghetti et al., corresponding to a chromophobe renal tumor and yielding a 7.7% positive margin rate (22). No positive margins were observed in the

studies by Abdelhakim and Abdelwahab or Reeves et al., while Zafar et al., Dal Moro et al., and Hussein et al. did not report margin status (9,13,30,34,39). Lymph node assessment was limited; only Meneghetti et al. performed hilar lymph node dissections in two cases, both of which were negative for metastasis (22).

Chapter 5: Discussion

The results from the initial experiences with the Versius robotic system in prostate and kidney surgery can be interpreted as demonstrating the feasibility and early effectiveness of this new platform for a range of urological procedures. However, the data also reveal considerable variability across different studies and surgeons, reflecting the early stages of adoption and the learning curves associated with a new technology.

5.1 INTERPRETATION OF PROSTATE SURGERY RESULTS

The dominance of RARP often with BPLND, indicates that this was the initial focus for many urological surgeons adopting the Versius system. This likely leverages the established robotic surgery workflows and surgeon experience from other platforms like daVinci.

The reported age range (50s to early 70s) and prevalence of overweight to obese BMIs are consistent with typical patient populations undergoing RARP (40). However, the younger cohorts reported by Hussein et al. – though for a small subset of RASPs within a larger transition – and Zafar et al. highlight potential variation in patient selection (13,30).

The successful use of both transperitoneal and extraperitoneal approaches, along with variations in Trendelenburg positioning and port placement adjustments based on patient factors (BMI, anatomy, height), suggests the Versius system allows for adaptation to different surgical preferences and patient characteristics. The consistent use of 3 or 4 BSUs points towards a degree of standardisation in setup.

The wide ranges in set-up, console, and total surgery times, with some studies reporting faster times and others significantly longer likely reflect varying levels of surgeon experience with robotic surgery and the Versius system itself. The separate reporting of early and later cases by Abdelhakim and Abdelwahab, showing improved times with experience, provides direct evidence of a learning curve (19). The higher initial conversion rate in Dibitetto et al.'s (June 2024) early experience further supports this (12). Reeves et al.’s extended operative times may reflect either early-stage

adoption, complex cases, or lack of system familiarity (9). Low overall complication rates support the safety of the Versius system in prostate surgery. High-grade complications (e.g., rectal fistula, port-site herniation) were rare but illustrate the importance of experience and procedural standardization.

While postoperative PSA levels were generally low, indicating successful tumour removal, the significant variation in PSM rates (0% to 83.3%) is a key area for interpretation. The exceptionally high rate in De Maria et al.'s small study, despite no reported technical difficulties, warrants further investigation and could be attributed to case selection (high rates of extracapsular disease) or surgeon experience (17). The gradual improvement in bladder continence over time, as demonstrated by Abdelhakim et al., is a crucial functional outcome but the lack of consistent reporting across all studies makes broad comparisons challenging (10). The inconsistent reporting of detailed TNM and Gleason staging across studies limits the ability to fully assess oncological outcomes and compare them effectively.

5.2 INTERPRETATION OF KIDNEY SURGERY RESULTS

The application of Versius across RAPN, RASN, and RARN demonstrates its versatility for various kidney surgeries. Zafar et al.'s high overall volume suggests a more rapid adoption for these procedures in their centre (13). Meneghetti et al.'s use of HLND and conversion to RARN demonstrates the system's applicability in complex renal surgeries (22).

The wider age range compared to prostate surgery reflects the broader spectrum of conditions requiring nephrectomy. Variability in BMI also likely corresponds to different underlying pathologies and patient profiles.

The consistent use of a lateral decubitus position and 3 BSUs, with adjustments for patient anatomy and BMI in port placement, mirrors the findings in prostate surgery regarding technical adaptability.

Operative times varied considerably not only between studies but also across the different types of nephrectomies (RASN, RARN, RAPN). RAPN showed the widest range in operative times, suggesting it may pose more technical challenges for new users compared to RARN and RASN. Conversion rates, while generally low in RAPN series, were noted in RASN and RARN, often due to adhesions, highlighting a

potential challenge in patients with prior abdominal surgery. EBL also showed significant variability depending on the procedure and the specific study.

The inconsistent reporting of PADUA scores, lesion size, and particularly TNM staging in kidney surgery makes it difficult to draw firm conclusions about oncological outcomes and case complexity across studies. The postoperative death in Zafar et al. was unrelated to system performance but underscores the need for careful patient selection in early-phase adoption (13). The low positive surgical margin rate in the reported series is encouraging. Though the limited data on lymph node pathology prevents a comprehensive assessment of nodal involvement and reflects a need for more thorough oncological outcome reporting in future studies.

5.3 TECHNICAL ADVANTAGES AND LIMITATIONS OF VERSIUS

The Versius introduces a modular and portable approach to robotic-assisted surgery. Its design allows individual BSUs to be easily maneuvered within and between operating rooms, facilitating integration into existing surgical workflows without necessitating dedicated robotic operation rooms (12,17,21). This flexibility supports its application across various specialties, including urology, gynecology, colorectal, thoracic, pediatric, and general surgery (41–52). The system's compact footprint and compatibility with standard laparoscopic equipment make it particularly suitable for institutions with limited resources (1,2,12,17,21,31).

Ergonomically, Versius offers an open-console design that enables surgeons to operate in either seated or standing positions, reducing physical strain during lengthy procedures (5,12,19). The console’s configuration promotes effective communication between the surgical team, enhancing intraoperative coordination and enabling training opportunities (3,12). The system employs 5 mm-diameter, fully wristed instruments—the smallest available on the market—which allow for minimal incisions, potentially decreasing postoperative pain, infection rates, and scarring (12,17,21). These instruments also provide a high degree of dexterity and articulation, which facilitate anatomical dissection and suturing, particularly in confined spaces like the pelvis and retroperitoneum (3,17,19,22).

However, certain limitations have been identified. The 30 cm instrument length may restrict reach in some patients, particularly those with higher BMI or deeper anatomy, and was reported to hinder access in early procedures (9,19). The absence of haptic

feedback, a common limitation in robotic platforms, means surgeons rely entirely on visual feedback to estimate tissue resistance, though this is partially offset by the system's stereoscopic vision (19). Additionally, system setup—including BSU configuration, docking, and port calibration—can initially be complex and time-consuming (19,31), but improves significantly with experience and team training (12,19). Other technical issues reported include limited jaw strength of graspers and short bite of scissors, occasional instrument clashes in narrow pelvic spaces, and system alarms that may delay surgery even if not clinically significant (12,21,22).

In summary, the Versius system presents a flexible, ergonomic, and technically advanced solution for MIS. Its strengths in adaptability, surgeon comfort, and precision are supported by early clinical experiences. Nonetheless, continued development—particularly regarding instrument design, haptic feedback, and alarm optimization—will be essential for broader adoption and optimal performance across surgical specialties (10,13,15).

5.4 TRAINING, ADAPTATION, AND LEARNING CURVE WITH VERSIUS

The successful implementation of the Versius surgical system relies heavily on structured, multidisciplinary training for both surgeons and operating room teams (2). Across studies, comprehensive preclinical preparation—including didactic modules, virtual simulation, dry-lab exercises, cadaveric practice, and intraoperative proctoring—has been consistently emphasized as essential for optimizing system setup, enhancing docking efficiency, and fostering coordinated teamwork (17,19,31). Most programs included a combination of didactic modules, virtual simulation, dry-lab and cadaveric sessions, often followed by proctoring or telementoring during initial clinical cases (9,22,31). Training durations varied across studies but commonly involved 15–20 hours of combined instruction and simulation, with some centers implementing device-specific training benchmarks provided by the manufacturer (9,12).

Structured training has been shown to significantly shorten the Versius learning curve. For instance, Dibitetto et al. (June 2024) observed marked reductions in both console and setup times over the first 30 eRARP procedures, with console time stabilizing around 100 minutes and setup time reducing to a consistent 8 minutes after just seven cases. Importantly, no intraoperative complications occurred during this learning

phase, highlighting the safety of progressive adoption (12). Similar improvements in workflow efficiency and operative metrics have been reported by other early adopters (15).

Crucially, early evidence suggests that surgeons without prior robotic experience can safely and effectively adopt Versius. In a multi-specialty study by Dixon et al. (2021), novice robotic users trained on Versius achieved complication and conversion rates comparable to experienced surgeons, suggesting a relatively accessible learning curve when supported by appropriate instruction (16). Butterworth et al. (2021) further confirmed the program's effectiveness, reporting significant improvement in technical skills across all participants, particularly in robotic control and depth perception. While surgeons with extensive robotic backgrounds performed better overall, those with no experience reached proficiency by the end of the course. Interestingly, surgeons with limited prior exposure adapted more slowly in some domains than complete novices, suggesting that familiarity with other platforms may not always confer immediate advantages (4).

Despite these positive findings, several platform-specific challenges have been identified. These include adapting to the open console interface, understanding the modular bedside unit configuration, navigating the learning curve for port placement, and accounting for limited assistant workspace (13,31).

While prior experience with robotic platforms like the da Vinci may facilitate the transition to Versius, the extent to which these skills are transferable remains unclear. Overall, the evidence suggests that a combination of standardized preclinical training, thoughtful operative planning, and gradual clinical exposure is critical to ensuring safe outcomes and a successful adaptation curve with the Versius system.

5.5 COMPARATIVE OUTCOMES AND PRACTICAL DIFFERENCES IN ROBOTIC SYSTEMS

Although data remain limited, early evidence suggests that the Versius surgical system offers comparable performance to the well-established da Vinci platform across several clinical domains. Hussein et al. (2023) found no significant differences in perioperative outcomes between the two systems in nephrectomy procedures, aside from a modestly shorter operative time for partial nephrectomy with Versius (median 170 min vs. 185 min) (30). Meneghetti et al. (2024) also observed that their early

RAPN outcomes with Versius aligned favorably with historical trifecta outcomes from high-volume da Vinci centres (22).

Further comparative analysis by Dibitetto et al. (Sep 2024) reported non-inferior oncological and complication outcomes for eRARP performed with Versius when compared to published benchmarks for da Vinci-based procedures and confirmed that Versius can be safely integrated into routine clinical workflows. However, the study noted longer operative times with Versius and variations in lymphadenectomy rates and pathological N staging, indicating areas that may benefit from technical refinement and experience. As the largest comparative series to date, its conclusions remain limited by its retrospective, single-surgeon design and short-term (6-month) follow-up (36).

Beyond clinical outcomes, practical differences between the systems are increasingly relevant. Versius' smaller physical footprint and modular BSU design offer greater flexibility in operating room configuration, especially in space-constrained environments (10). Its lower acquisition and maintenance costs further enhance its appeal, particularly in low- and middle-income healthcare systems (21,53). This potential was underscored in a scoping review by Falola et al. (2024), which examined 1,328 robotic procedures across 16 African studies. While most surgeries were performed using the da Vinci platform, isolated cases employed Versius and Senhance. The review revealed promising short-term outcomes—namely, a low pooled conversion rate (0.21%) and no reported mortality—but noted that robotic adoption remains limited to just three African countries. The authors emphasized that affordable platforms like Versius may help overcome current barriers such as limited infrastructure, training, and resources, enabling broader surgical access across the continent (54).

Economic and ergonomic considerations also factor into platform choice. The da Vinci system remains the most expensive on the market, whereas Versius has been designed with cost-effectiveness and scalability in mind (55). In terms of surgeon ergonomics, Dixon et al. (2024) demonstrated that Versius significantly reduces physical strain in robotic-assisted colorectal procedures compared to traditional laparoscopy. The study found that the open-console design led to lower Rapid Entire Body Assessment (REBA) scores—indicating reduced musculoskeletal injury risk—and less cognitive fatigue (NASA-Task Load Index: 32.4 vs. 45.6) without compromising surgical

outcomes or team communication. These findings suggest that open-console systems like Versius may offer under-recognized occupational health benefits that contribute to long-term surgical performance and job sustainability (56).

Nonetheless, the global uptake of Versius remains modest, hindered by its smaller user base and more limited training infrastructure compared to da Vinci (10). As a result, widespread integration may require further expansion of training programs and long-term comparative data. Future research should include prospective, multicenter studies evaluating clinical performance, learning curves, and cost-effectiveness across diverse surgical indications to more fully define the role of Versius within the evolving landscape of robotic surgery.

5.6 FEASIBILITY AND SAFETY OF VERSIUS

Initial clinical experiences suggest that the Versius robotic platform is both feasible and safe for urological procedures, including RAP and RAN. Across studies, RARP and RAPN were consistently performed with low complication rates and acceptable perioperative outcomes, aligning with results from more established robotic systems as seen in Abdelhakim et al. (2025) and Zafar et al. (10,13). De Maria et al. and Rocco et al. (Feb 2023) both confirmed the feasibility of RARP with Versius, emphasizing that procedural success depends heavily on correct trocar positioning and system set-up (17,31).

Similarly, RAPN using Versius has demonstrated favourable results in experienced hands, particularly when managing complex renal tumors (22,34). Meneghetti et al. highlighted excellent perioperative outcomes in their RAPN series, noting that careful operating room configuration and team familiarity with the platform were key to success (22). These findings align with broader reports showing that, with appropriate preparation, Versius can be implemented effectively even in institutions transitioning from other systems (21,31). As summarized by Zafar et al., the system has shown a favourable safety profile and promising early results in patient care, reinforcing its potential role in the future of minimally invasive urological surgery.

Furthermore, as presented by Soumpasis et al. (Feb 2023) and Soumpasis et al. (Oct 2023), Versius has a prospective, multicenter surgical registry integrated. Established to support the clinical introduction of Versius, it also monitors its performance across the broad range of specialties, including general, colorecta, gynecological, urological,

and thoracic surgery. The registry captures comprehensive pre-, intra-, and postoperative data to monitor the safety and effectiveness of the Versius system. Early analysis of 2,083 cases showed low rates of adverse events, conversions, and mortality, supporting its safe clinical adoption. Beyond surveillance, real-time analytics like cumulative sum (CUSUM) and funnel plots enable quality improvement and performance tracking. The registry also supports risk factor identification and targeted training, making it a vital tool for the evidence-based integration of new robotic technologies (57,58).

5.7 CURRENT LIMITATIONS IN RESEARCH AND FUTURE OUTLOOK

While current evidence supports the early safety, feasibility, and functional applicability of Versius in prostate and kidney surgeries, several critical gaps remain. Most notably, the need for larger-scale, prospective, and multicenter studies is frequently emphasized to establish reproducibility and standardize outcome reporting across diverse settings (19,21,31).

Future research should aim to directly compare Versius with other robotic platforms, particularly da Vinci, using consistent metrics to evaluate surgical, functional, and oncological outcomes (10,31). Longer-term follow-up is also essential to validate early findings, especially in terms of positive surgical margins, recurrence rates, continence, and renal function preservation (10,13). Furthermore, detailed investigation into learning curves, workflow integration, and the cost-effectiveness of Versius across various hospital settings will be important to support its broader adoption.

Finally, the adaptability of Versius offers unique opportunities for tailoring robotic surgery to specific patient groups and institutional capacities. However, widespread integration will depend on accumulating robust evidence from real-world clinical experience and ensuring comprehensive training to minimize early technical limitations and variability in surgical outcomes.

Chapter 6: Conclusion

Overall, the Versius robotic system has shown high reliability and efficiency, with malfunctions and alarms having minimal impact on procedural safety or outcomes. Its adaptability, driven by optimized patient positioning, trocar configurations, and effective troubleshooting, contributes to reduced setup times and consistent success rates, highlighting its robustness and reliability in robotic-assisted surgeries.

The early clinical application of the Versius surgical system in prostate and kidney procedures demonstrates clear potential as a safe, effective, and flexible alternative in the field of robot-assisted urology. Its modular design, ergonomic improvements, and lower infrastructural demands make it particularly attractive for institutions seeking cost-effective and adaptable robotic platforms.

Despite the generally positive perioperative outcomes and procedural feasibility observed across studies, the current literature is largely based on small, single-center cohorts representing initial adoption phases. This, alongside variability in outcome reporting—particularly for key oncological and functional indicators such as TNM staging, Gleason scores in prostatectomies, and postoperative continence data—limits the generalizability and comparability of existing findings. Inconsistent use of follow-up intervals and definitions for surgical metrics such as operative time and PSA measurements further complicates cross-study evaluation.

Nonetheless, these limitations are characteristic of the early implementation phase of any new surgical technology. Importantly, the data to date indicate that the learning curve is navigable, and that the system can be integrated into existing surgical workflows with relative ease. The positive early experiences—especially in terms of safety, surgical efficiency, and ergonomics—lay a strong foundation for further expansion.

Looking forward, the success of Versius will depend on well-designed, prospective, multicenter studies with standardized outcome reporting and longer follow-up. Such efforts will be key in validating its clinical value and establishing its long-term role in

urological surgery. If this momentum continues, Versius may not only complement existing systems but expand access to high-quality robotic surgery worldwide.

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Appendices

Appendix A

Table 1: Robot-assisted Prostatectomies with Versius in Prostate Surgery: Set-up, Instruments, and Surgeon Experience

	Procedure(s)		Versius set-up			Instrument, port size, mm (n)			Surgeon Experience	
Author (Publication Year, Country, Study Design)	**In total, n**	**RAP, n (%)**	**Patient positioning**	**Procedure approach**	**BSUs used, n**	**Endoscope**	**Robotic arms (BMG, MCS, FG)**	**Accessory port(s)**	**Surgeon(s), n**	**Experience, RLP/year, n**
Abdelhakim et al. (2025, Egypt, PS)	118	95 (80.5) RARP w/BPLND 23 (19.4) RARP	Steep TDB	TP	4	1 (10-mm)	3 (10-mm)	1 (10-mm)	3	senior (1), trainee surgeons (2)
Zafar et al. (2025, Pakistan, ROS)	150	3 (2) RARP	N/A	N/A	3	1 (11mm)	2 (5mm)	N/A	2	13-14 years in urological
Dibitetto et al. (Sep 2024, Italy, CA)	106	49 (46.23) eRARP w/Versius 4 (3.7) eRARP w/BPLND w/Versius 38 (35.85) eRARP w/daVinci 15 (14.15) eRARP w/BPLND w/daVinci	10° TDB	EP	4	1 (N/A)	3 (N/A)	1 (5-mm)	1	Extensive robotic surgery w/daVinci and w/Versius
Dibitetto et al. (June 2024, Italy, RCS)	53	35 (66.04) eRARP 18 (33.96) eRARP + BPLND	10° TDB	EP	4	1 (N/A)	3 (N/A)	1 (5-mm)	1	>1000 RLPs
Polom and Matuszewski (2024, Poland, RCS)	58	58 (100) RARP	20° TDB	TP	3-4	1 (12-mm)	2 (7-mm)	1 (12-mm) 1 (5-mm)	N/A	N/A
Abdelhakim and Abdelwahab (2023, Egypt, CS)	30	25 (83.3) RARP w/BPLND 5 (16.67) RARP	Steep TDB	TP	4	1 (12-mm)	3 (12-mm)	1 (12-mm)	1	> 600 RLPs, no robotic exp.
Rocco et al. (June 2023, Italy, CS)	3	1 (33.33) RARP w/Versius 1 (33.33) RARP w/Hugo RAS 1 (33.33) RARP w/DaVinci	N/A	N/A	N/A	N/A	N/A	N/A	1	>1500 robotic surgeries w/DaVinci
Hussein et al. (2023, Pakistan, MCS)	106	9 (8.49) RASP	N/A	N/A	4	1 (N/A)	3 (5-mm)	1 (12-mm or 15-mm)	3	Robotic surgeries w/DaVinci
Rocco et al. (Feb 2023, Italy, CR)	1	1 (100) RARP	25° TDB	N/A	4	1 (N/A)	3 (N/A)	2 (N/A)	1	1500 RARP w/DaVinci
De Maria et al. (2023, Itay, CS)	18	13 (72.22) RARP 5 (27.78) RARP + BPLND	28° TDB	TP	4	1 (10-mm)	3 (5-mm)	1 (10-mm) 1 (5-mm)	1	500 RARPs w/DaVinci and Xi
Reeves et al. (2022, UK, CS)	10	4 (40) RARP	N/A	N/A	3	1 (10-mm)	2 (5-mm)	1 (12-mm) 2 (5-mm)	1	3500 robotic surgeries w/DaVinci

Appendix B

Table 2: Robot-assisted Prostatectomies with Versius in Prostate Surgery: Key Metrics of Efficiency, Estimated Blood Loss, Inpatient Stay and Complications

	Procedure(s)		Key metrics of efficiency				Estimated blood loss	Inpatient stay	Complications, Clavien-Dindo Grade, n (%)		
Author (Publication Year, Country, Study Design)	**In total, n**	**RAP, n (%)**	**Set-up time, median (IQR) or mean ± s.d., min**	**Console time, median (IQR) or mean ± s.d., min**	**Total surgery time, median (IQR) or mean ± s.d., min**	**Conversion(s), n (%)**	**Median (IQR) or mean ± s.d., mL**	**Median (IQR) or mean ± s.d., days**	**Grade I**	**Grade II**	**Grade III**
Abdelhakim et al. (2025, Egypt, PS)	118	95 (80.5) RARP w/BPLND 23 (19.4) RARP	13.17 ± 1.157	194.75 ± 24.3	225.76 ± 25	0	307.46 ± 61.44	2.16 ± 0.867	12 (10.17) intraop blood transfusion	N/A	1 (0.84) urethracutaneous fistula, repaired after 6 mo 1 (0.84) intraperitoneal urine leakage
Zafar et al. (2025, Pakistan, ROS)	150	3 (2) RARP	7.33 ± 1.70	151.67 ± 43.34	223.67 ± 54.27	0	123.33 ± 55.58	1.33 ± 0.47	N/A	N/A	N/A
Dibitetto et al. (Sep 2024, Italy, CA)	106	49 (46.23) eRARP w/Versius 4 (3.7) eRARP w/BPLND w/Versius 38 (35.85) eRARP w/daVinci 15 (14.15) eRARP w/BPLND w/daVinci	N/A	N/A	170 (158-202)	N/A	350 (100-600)	3 (2-6)	N/A	N/A	4 (6)
Dibitetto et al. (June 2024, Italy, RCS)	53	35 (66.04) eRARP 18 (33.96) eRARP + BPLND	15 (8-30)	100 (63-240)	130 (80-260)	0 to open 4 (7.54) hybrid	100 (30-300)	3 (2-6)	0	2 (3.77) UTI treated w/antibiotics	0
Polom and Matuszewski (2024, Poland, RCS)	58	58 (100) RARP	N/A	150.9 (62-279)	213 (128-348)	1 (1.72) to open	437 (210-2050)	4.5 (4-12)	0	2 (3.45)	4 (3.45) unspecified
Abdelhakim and Abdelwahab (2023, Egypt, CS)	30	25 (83.3) RARP w/BPLND 5 (16.67) RARP	10 (7-12) in last 21 cases	130 (120-145) in last 21 cases	153 (140-165) in last 21 cases	0	231.67 (181.56-281,78)	2 (1-2)	1 (3.3) intraop blood transfusion	N/A	none > Grade II
Rocco et al. (June 2023, Italy, CS)	3	1 (33.33) RARP w/Versius 1 (33.33) RARP w/Hugo RAS 1 (33.33) RARP w/DaVinci	N/A	130 RARP w/Versius	N/A	0	<100 all RARPs	3-4 all RARPs	0	0	0
Hussein et al. (2023, Pakistan, MCS)	106	9 (8.49) RASP	N/A	N/A	150 (110-180) for all procedures	6 (5.66) to open, for all procedures	123 (40-500) for all procedures	3 (2-4) for all procedures	N/A	N/A	N/A
Rocco et al. (Feb 2023, Italy, CR)	1	1 (100) RARP	30	130	N/A	0	N/A	3	0	0	0
De Maria et al. (2023, Itay, CS)	18	13 (72.22) RARP 5 (27.78) RARP + BPLND	8.5 (7-10)	201 (170-242)	226 (201-277)	0	140 (100–550)	4 (3.75-5; 3-13)	14 (77.78) analgesics	1 (5.56) UTI treated w/antibiotics	1 (5.56) bowel obstruction due to port-site hernia requiring surgical correction
Reeves et al. (2022, UK, CS)	10	4 (40) RARP	15 (11-24)	272 (195-377)	335 (258-440)	0	N/A	N/A	1 (25) urine leak	0	0

Appendix C

Table 3: Robot-assisted Prostatectomies with Versius in Prostate Surgery: Morbidity

	Procedure(s)		Preoperative Data					Pathology			
Author (Publication Year, Country, Study Design)	**In total, n**	**RAP, n (%)**	**Preoperative PSA levels, mean (range), ng/mL**	**Prostate volume, mean (range), cm3**	**cT-stage, n (%)**	**cN-stage, n (%)**	**Gleason score at transrectal biopsy, n (%)**	**pT-stage, n (%)**	**Gleason score at final pathology report, n (%)**	**Surgical margins, pos, n (%)**	**Lymph node pathology, neg, n(%)**
Abdelhakim et al. (2025, Egypt, PS)	118	95 (80.5) RARP w/BPLND 23 (19.4) RARP	9 (4.16-64)	50 (20-167)	cT1b, 1 (0.8) cT1c, 52 (44.1) cT2a, 23 (19.5) cT2b, 21 (17.8) cT2c, 11 (9.3) cT3a, 6 (5.1) cT3b, 4 (3.4)	cN0, 112 (94.9) cN1, 6 (5.1)	6 (3+3), 23 (19.5) 7 (3+4), 62 (52.5) 7 (4+3), 18 (15.3) 8 (4+4), 14 (11.9) 9 (4+5), 1 (0.8)	pT2a, 7 (5.9) pT2b, 35 (29.7) pT2c, 65 (55.1) pT3a, 5 (4.2) pT3b, 6 (5.1) pNx, 23 (19.5) pN0, 78 (66.1) pN1, 17 (14.4)	6 (3+3), 6 (5.1) 7 (3+5), 59 (50) 7 (4+3), 30 (25.4) 8 (4+4), 9 (7.6) 9 (4+5), 11 (9.3) 9 (5+4), 2 (1.7) 10 (5+5), 1 (0.8)	0 (100)	78 (82.1) pN0
Zafar et al. (2025, Pakistan, ROS)	150	3 (2) RARP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 (33.34)	no removal
Dibitetto et al. (Sep 2024, Italy, CA)	106	49 (46.23) eRARP w/Versius 4 (3.7) eRARP w/BPLND w/Versius 38 (35.85) eRARP w/daVinci 15 (14.15) eRARP w/BPLND w/daVinci	7.8 (5.2-10.4)	42 (31-75)	Clinical T stage Unpalpable; cT1, 45 (85) Palpable; cT2-cT3, 8 (15) MRI T stage T2, 36 (68) T3a-b, 17 (32)	N/A	Scores converted from ISUP group: 2-6, 12 (25) 7 (3+4), 13 (25) 7 (4+3), 14 (26) 8 (4+4, 3+5, 5+3), 12 (23) 9-10, 1 (2)	pT2, 38 (72) pT3a 14 (26) pT3b, 1 (2) pNx, 49 (92) pN0, 2 (4) pN1, 2 (4)	Scores converted from ISUP group: 2-6, 10 (19) 7 (3+4), 15 (28) 7 (4+3), 15 (28) 8 (4+4, 3+5, 5+3), 11 (21) 9-10, 2 (4)	9 (17)	2 (4) pN0
Dibitetto et al. (June 2024, Italy, RCS)	53	35 (66.04) eRARP 18 (33.96) eRARP + BPLND	6.6 (4.3-20.5)	58 (32-115)	Exclusion criteria: T4	N/A	Scores converted from ISUP Grade: Scores not reported in detail, ranged from 2 to 10	8 (15%) patients w/adjuvant radiotherapy after surgery due to PSM, positive nodes and/or high risk final ISUP pN0, 53 (100) pM0, 53 (100)	N/A	8 (15.1)	N/A
Polom and Matuszewski (2024, Poland, RCS)	58	58 (100) RARP	9.8 (1.9-29.4)	48.5 (21-120)	N/A	25 (48) MRI w/ suspicion of extraprostatic disease	Scores converted from risk groups: ≤ 6, 7 (12.06) 7 (3+4) - 7 (4+3), 40 (68.96) 8 - 10, 11 (18.9)	27 (46.5) extraprostatic disease	N/A	15 (25.8)	no removal
Abdelhakim and Abdelwahab (2023, Egypt, CS)	30	25 (83.3) RARP w/BPLND 5 (16.67) RARP	5.7 (2-27)	33.131 (20-150)	cT1b, 1 (3.3) cT1c, 9 (30) cT2a, 8 (26.7) cT2b, 10 (33.3) cT2c, 1 (3.3) cT3b, 1 (3.3)	cN0, 29 (96.7) cN1, 1 (3.3)	6 (3+3), 6 (20) 7 (3+4), 14 (46.7) 7 (4+3), 6 (20) 8 (4+4), 4 (13.3)	pT2a, 12 (40) pT2b, 10 (33.3) pT2c, 6 (20) pT3a, 1 (3.3) pT3b, 1 (3.3) pNx, 5 (16.67) pN0, 23 (76.67) pN1, 2 (6.6)	6 (3+3), 4 (13.33) 7 (3+4), 18 (60) 7 (4+3), 6 (20) 8 (4+4), 1 (3.3) 9 (4+5), 1 (3.3)	2 (6.67)	23 (92) pN0
Rocco et al. (June 2023, Italy, CS)	3	1 (33.33) RARP w/Versius 1 (33.33) RARP w/Hugo RAS 1 (33.33) RARP w/DaVinci	6 RARP w/Versius	40 (at pathology report) RARP w/Versius	cT1c, RARP w/Versius	cN0, RARP w/Versius	7 (3+4), RARP w/Versius	pT2c RARP w/Versius	7 (3+4) RARP w/Versius	0 RARP w/Versius	no removal
Hussein et al. (2023, Pakistan, MCS)	106	9 (8.49) RASP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	no removal
Rocco et al. (Feb 2023, Italy, CR)	1	1 (100) RARP	6	N/A	N/A	N/A	7 (3+4)	pT2c	7 (3+4)	0	no removal
De Maria et al. (2023, Itay, CS)	18	13 (72.22) RARP 5 (27.78) RARP + BPLND	15 (7-25)	N/A	cT1c, 6 (33.3) cT2a, 10 (55.5) cT2b, 1 (5.6) cT2c, 1 (5.6)	N/A	6, 2 (11.1) 7 (3+4), 5 (27.8) 7 (4+3), 9 (50) 8 (4+4), 2 (11.1)	pT2c, 7 (38.9) pT3a, 9 (50) pT3b, 2 (11.1) pN0, 18 (100) pM0, 18 (100)	7 (3+4), 10 (55.6) 7 (4+3), 7 (38.9) 9 (4+5), 1 (5.5)	15 (83.3)	5 (100)
Reeves et al. (2022, UK, CS)	10	4 (40) RARP	N/A	N/A	N/A	N/A	Scores converted from ISUP Grade: 7 (3+4), 2 (50) 7 (4+3), 1 (25) 9-10, 1 (25)	pT2, 4 (100)	N/A	0	no removal

Appendix D

Table 4: Robot-assisted Prostatectomies with Versius in Prostate Surgery: Patient Demographics and Functional Outcomes

	Procedure(s)		Patient Demograpics			Functional Outcomes		
Author (Publication Year, Country, Study Design)	**In total, n**	**RAP, n (%)**	**Patient(s), n**	**Age, median (IQR) or mean ± s.d., years**	**BMI, median (IQR) or mean ± s.d., kg/m²**	**Catheter duration, median (IQR) or mean ± s.d., days**	**Full continence evaluation, n (%)**	**Postop undetectable PSA, n (%)**
Abdelhakim et al. (2025, Egypt, PS)	118	95 (80.5) RARP w/BPLND 23 (19.4) RARP	118	64.26 ± 7.13	30.28 ± 4	7.26 ± 1.441	28 (23.7) after 1 week 42 (35.6) after 1 mo 58 (49.2) after 3 mo 97 (82.2) after 6 mo 107 (90.7) after 12 mo	At 1.5, 3 and 6 mo: 111 (94.07)
Zafar et al. (2025, Pakistan, ROS)	150	3 (2) RARP	3	50.67 ± 21.75	25.23 ± 4.81	7-10	2 (66.67) after 3 mo	At 6 mo: 3 (100) < 0.04 ng/mL
Dibitetto et al. (Sep 2024, Italy, CA)	106	49 (46.23) eRARP w/Versius 4 (3.7) eRARP w/BPLND w/Versius 38 (35.85) eRARP w/daVinci 15 (14.15) eRARP w/BPLND	53 w/Versius	66 (61-72)	27 (23-32)	7 (5-15)	25 (47) after 1 mo 29 (55) after 3 mo 36 (68) after 6 mo	N/A
Dibitetto et al. (June 2024, Italy, RCS)	53	35 (66.04) eRARP 18 (33.96) eRARP + BPLND	53	67 (48-73)	N/A	7	N/A	N/A
Polom and Matuszewski (2024, Poland, RCS)	58	58 (100) RARP	58	66.9 (52-75)	27.3 (19-36)	7.9 (7-21)	52 (89.7) after 6 weeks	At 1.5 mo: 56 (96.5)
Abdelhakim and Abdelwahab (2023, Egypt, CS)	30	25 (83.3) RARP w/BPLND 5 (16.67) RARP	30	67 (52-72)	29.73 (23.78-38.75)	7 (7-10)	5 (16.6) after 1 week 9 (30) after 1 mo 18 (60) after 2 mo 27 (90) after 3 mo	At 3 mo: 28 (93.33)
Rocco et al. (June 2023, Italy, CS)	3	1 (33.33) RARP w/Versius 1 (33.33) RARP w/Hugo RAS 1 (33.33) RARP w/DaVinci	3	72 RARP w/Versius	25 RARP w/Versius	N/A	N/A	N/A
Hussein et al. (2023, Pakistan, MCS)	106	9 (8.49) RASP	106	42 (26-56)	N/A	N/A	N/A	N/A
Rocco et al. (Feb 2023, Italy, CR)	1	1 (100) RARP	1	72	25	N/A	social continence 3 days after catheter removal	N/A
De Maria et al. (2023, Itay, CS)	18	13 (72.22) RARP 5 (27.78) RARP + BPLND	18	70 (55-76)	27 (24–30)	8 (7-14)	10 (55.5) after 1 mo 13 (72.2) after 2 mo	At 8 weeks: 17 (94.4) ≤ 0.05 ng/mL
Reeves et al. (2022, UK, CS)	10	4 (40) RARP	4	66	28	17.5 (11-33)	2 (50) after 1 week	N/A

Appendix E

Table 5: Robot-assisted Kidney Survery with Versius: Set-up, Instruments and Surgeon Experience

	Procedure(s)		Versius Set-up			Instrument, port size, n (mm)			Surgeon Experience	
Author (Publication Year, Country, Study Design)	**In total, n**	**RAN, n (%)**	**Patient positioning**	**Procedure approach**	**BSUs used, n**	**Endoscope**	**Robotic arms (BMG, MCS, FG)**	**Accessory port(s)**	**Surgeon(s), n**	**Experience, RLP /year, n**
Dal Moro et al. (2025, Italy, CS)	1	1 RASN	LD	RP	3-4	1	2-3	1 (10-mm)	1	
Zafar et al. (2025, Pakistan, ROS)	150	55 (36.67) RASN 36 (24) RARN	N/A	N/A	3	1 (11mm)	2 (5mm)	N/A	2	13-14 years surgical experience incl. Robotic surgery
Abdelhakim and Abdelwahab (2024, Egypt, CS)	30	30 (100) RAPN	LD	TP	3	1 (10-mm)	2 (10-mm)	1 (10-mm) 1 (5-mm)	1	Extensive experience w/LPN
Meneghetti et al. (2024, Italy, MCCS)	15	11 (73.33) RAPN, 2 (13.33) RAPN + HLND 2 (13.33) RAPN converted to RARN	30° modified LD	TP	3	1 (12-mm)	2 (5-mm)	1 (10-mm) 1 optionally (5-mm)	2	Extensive experience w/daVinci, previously 20 RARPs w/Versius Extensive experience w/LPN
Hussein et al. (2023, Pakistan, MCCS)	106	42 (39.62) RASN 10 (9.43) RARN 6 (5.66) RAPN	LD	N/A	3	1	2 (5-mm)	1-2 (12-mm or 15-mm)	3	Extensive experience w/daVinci
Reeves et al. (2022, UK, CS)	10	2 (20) RARN	N/A	N/A	3	1 (10-mm)	2 (5-mm)	2 (5-mm) 1 (12-mm)	1	Extensive experience w/robotic surgery, 3500 Extensive experience w/daVinci, 1800

Appendix F

Table 6: Robot-assisted Kidney Survery with Versius: Key Metrics, Estimated Blood Loss, Inpatient Stay and Complications

	Procedures		Key metrics of efficiency				Estimated blood loss	Inpatient stay	Complications, Clavien-Dindo Grade, n (%)		
Author (Publication Year, Country, Study Design)	**In total, n**	**RAN, n (%)**	**Set-up time, median (IQR) or mean ± s.d., min**	**Console time, median (IQR) or mean s.d., min**	**Total surgery time, median (IQR) or mean ± s.d., min**	**Conversion(s), n (%)**	**Median (IQR) or mean ± s.d., mL**	**Median (IQR) or mean ± s.d., days**	**Grade I**	**Grade II**	**Grade III**
Dal Moro et al. (2025, Italy, CS)	1	1 RASN	16	110	N/A	0	N/A	N/A	0	0	0
Zafar et al. (2025, Pakistan, ROS)	150	55 (36.67) RASN 36 (24) RARN	9.75 ± 4.01 RASN 9.86 ± 5.01 RARN	86.75 ± 41.52 RASN 82.58 ± 29.43 RARN	143.47 ± 47.32 RASN 146 ± 45.90 RARN	3 (5.45) RASN to open 1 (2.78) RARN to open	132.31 ± 320.52 RASN 57.83 ± 32.29 RARN	1.75 ± 1.49 RASN 1.91 ± 1.36 RARN	For all 150 procedures: 1 (0.7) fever	6 (4) surgical site infections requiring medication 5 (3.3) UTI requiring medication	0
Abdelhakim and Abdelwahab (2024, Egypt, CS)	30	30 (100) RAPN	9.17 ±0.91	149 ± 14.27	177.17 ±29.53	0	154.33 ± 67.19	2.37 ± 0.49	4 (13.34) intraoperative blood transfusion	0	1 (3.34) urine leakage w/DJ insertion
Meneghetti et al. (2024, Italy, MCCS)	15	11 (73.33) RAPN, 2 (13.33) RAPN + HLND 2 (13.33) RAPN converted to RARN	13 (12-14)	75 (66-80)	105 (100-110)	0	200 (100-250)	4 (3-4)	1 (6.67) fever requiring antibiotic therapy	0	N/A
Hussein et al. (2023, Pakistan, MCCS)	106	42 (39.62) RASN 10 (9.43) RARN 6 (5.66) RAPN	N/A	N/A	145 (115-170) RASN 167 (160-190) RARN 170 (140-180) RAPN	2 (4.76) RASN to open 1 (10) RARN to open 0 RAPN to open	100 (50-200) RASN 200 (100-600) RARN 450 (150-500) RAPN	4 RASN 3 (2-4) RARN N/A RAPN	N/A	Perioperative transfusions: 6 (14.28) RASN 4 (40) RARN 2 (33.33) RAPN	N/A
Reeves et al. (2022, UK, CS)	10	2 (20) RARN	14 (13-14)	110 (93-127)	157 (132-181)	0	N/A	N/A	0	0	0

Appendix G

Table 7: Robot-assisted Kidney Survery with Versius: Patient Demographics, and Morbidity

	Procedures		Patient Demographics				Preoperative Data			Pathology			
Author (Publication Year, Country, Study Design)	**In total, n**	**RAN, n (%)**	**Patient(s), n**	**Age, median (IQR) or mean ± s.d., years**	**Gender, males, n (%)**	**BMI, mean ± s.d., kg/m²**	**Lesion size, preop imaging, median (IQR), cm**	**PADUA score**	**cT-stage, n (%)**	**pT-stage, n (%)**	**Surgical margins, pos, n (%)**	**Lymph node pathology, neg, n (%)**	**Mortality, n (%)**
Dal Moro et al. (2025, Italy, CS)	1	1 RASN	1	65	1	27	N/A	N/A	small non-functioning left kidney	N/A	N/A	N/A	0
Zafar et al. (2025, Pakistan, ROS)	150	55 (36.67) RASN 36 (24) RARN	91	43.20 ± 15.88 RASN 54.44 ± 12.59 RARN	77 (51.3) for all procedures	22.42 ±4.43 RASN 25.69 ± 4.28 RARN	N/A	N/A	N/A	N/A	N/A	N/A	1 (1.81) RASN
Abdelhakim and Abdelwahab (2024, Egypt, CS)	30	30 (100) RAPN	30	51.27 ± 12.96	12 (40)	27.96 ± 3.71	5 (2-8)	9.5 (8-11)	N/A	pT1a, 5 (16.67) pT1b, 17 (56.67) pT2a, 8 (26.67) 24 (80) clear cell RCC 6 (20) papillary cell RCC	0 (100)	no removal	0
Meneghetti et al. (2024, Italy, MCCS)	15	11 (73.33) RAPN, 2 (13.33) RAPN + HLND 2 (13.33) RAPN converted to RARN	15	64 (55-69)	6 (40)	N/A	3.75 (2.1-5) single lesion	8 (7-9)	cT1-T2c N0-N1 M0	N/A	1 (6.67) w/chromo-phobe tumor	2 (100)	0
Hussein et al. (2023, Pakistan, MCCS)	106	42 (39.62) RASN 10 (9.43) RARN 6 (5.66) RAPN	58	35 (25-50) RASN 56 (47-60) RARN 45 (26-50) RAPN	25 (59.52) RASN 6 (60) RARN 3 (50) RAPN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Reeves et al. (2022, UK, CS)	10	2 (20) RARN	2	41	N/A	26	N/A	N/A	1 (50) benign / non functioning destructed 1 (50) T1b Grade 2 clear cell	N/A	0	N/A	0