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RESEARCH

Long term experience of robotic retroperitoneal partial nephrectomy as the default approach in the management of renal masses: should the paradigm shift?

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Abstract

Although retroperitoneal surgery has demonstrated a better quality of recovery compared to transperitoneal routes, Retroperitoneal Robot Assisted Partial Nephrectomy (RRAPN) remains proportionally infrequent. As the boundaries of what is achievable robotically continue to be pushed, we present our experience at a high-volume tertiary referral centre that specialises in retroperitoneal surgery, exploring its feasibility as standard of care in the management of small renal masses. A prospective database of 784 RAPNs (2009–2020) was reviewed and 721 RRAPNs (92%) were performed at our centre. In our practice, we utilise a four-port approach to RRAPN. Patient, tumour and operative characteristics were assessed and both oncological outcomes and trifecta and pentafecta achievements were determined. Pentafecta was defined as achieving trifecta (negative surgical margin, no post-operative complications and WIT of <25 min) plus over 90% estimated GFR preservation and no CKD stage upgrading at 1 year. Multivariate analysis was conducted to predict peri-operative factors which may prevent achieving a trifecta/pentafecta outcome. From 784 cases, 112 RAPNs were performed for imperative reasons, whilst the remainder were elective. Mean BMI ± s.d amongst our cohort was 28.6 ± 5.7. Mean tumour size was 3.1 cm (range 0.8–10.5 cm) and 47% of cases were stratified as intermediate/high risk using R.E.N.A.L nephrometry scoring. Forty-six patients had lesions in a hilar location, and 31% were anterior. Median blood loss was 30mls, with an open conversion rate of 1% and transfusion rate of 1.6%. Median warm ischaemic time (WIT) was 21 min, positive surgical margins were found in 4% and our post-operative Clavien 3/> complication rate was 2.6%. We had a 1-day median length of stay with a 30 day readmission rate of 2%. Of 631 patients (80%) with a definitive histological diagnosis of cancer, 23% had T1b/> disease. Over a mean 15 month follow-up period (range 1–125 months), 2% of patients developed recurrences and our cohort demonstrated a 99% 5 year cancer specific survival. Trifecta was achieved in 67% of cases and pentafecta in 47%. Age ($p=0.05$), operative time ($p=0.008$), pT1b tumours ($p=0.03$), R.E.N.A.L score and blood loss ($p=0.001$) were found to statistically significantly influence achievement of trifecta. Pentafecta achievement was influenced by R.E.N.A.L score ($p=0.008$), operative time ($p=0.001$) and blood loss ($p=0.001$). We demonstrate the retroperitoneal approach in RAPN is feasible and safe irrespective of lesion location and complexity. In the hands of high-volume centres that are skilled in the retroperitoneal approach the benefits of retroperitoneal surgery can be extended even to challenging cohorts of patients without compromising their oncological or functional outcomes.

Keywords Robotic Partial Nephrectomy · Retroperitoneal Partial Nephrectomy · Retroperitoneal Robotic Partial Nephrectomy · Renal Cell Cancer · Kidney Cancer

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Introduction

Nephron sparing approaches are considered the standard of care in approaching the management of the small renal mass, now often biopsied to confirm or refute malignancy in many centres in the first instance. Partial nephrectomy remains the gold standard extirpative surgical approach for these small renal masses [1, 2], but the significant morbidity of open surgical routes has been eclipsed by the adoption of robotic surgical platforms meaning that nephron-sparing surgery has evolved into a minimally invasive procedure with short in patient stay, low levels of complications and an expansion of indication with ever more complex procedures being performed using this technology [3, 4].

Yet, most of the reported series of robotic assisted partial nephrectomy (RAPN) are performed via the transperitoneal route [5]. The transperitoneal approach (TP) provides a large working space and more familiar anatomical landmarks for the operating surgeon. However, reflection of the bowel is an essential step to gain access to the kidney. Consequently, there is an increased risk of bowel injury and developing post-operative ileus [6]. Indeed, transperitoneal robot assisted partial nephrectomy (TP-RAPN) is challenging when it comes to treating posterior tumours. Complete medial rotation of kidney and manipulation of the posterior tumour is typically required. Furthermore, TP-RAPN maybe an unattractive prospect in those patients with a history of extensive intraperitoneal disease and multiple surgical procedures e.g. Crohn's disease. In some cases, this may influence the recommended treatment options, with more emphasis on the role of percutaneous ablative techniques [7].

Retroperitoneal robot assisted partial nephrectomy (RP-RAPN) provides an excellent alternative surgical technique. It offers early hilar control, no peritoneal violation and earlier return of bowel habits. Owing to the retroperitoneal space, the majority of post-operative complications can be regularly managed conservatively [7]. In addition, retroperitoneal renoscopy causes less interference with ventilator and haemodynamic functions compared nephrectomy via the TP approach [8]. Reports would suggest that these potential advantages mean that RP-RAPN is becoming a more popular approach. Increasingly robotic renal surgeons are adopting RP-RAPN with comparable outcomes to those of TP-RAPN [5].

We are a large tertiary referral centre for upper tract oncology in the United Kingdom. Since the introduction of our robotic service in 2009 we have utilized the retroperitoneal approach to robotic partial nephrectomy as standard of care. This study explores our decade long experience with this technique in a high-volume setting and serves to illustrate the safety and feasibility of this approach. Furthermore, with significant resource pressures faced globally within healthcare due to the pandemic and its recovery, we explore the advantages of a paradigm shift towards retroperitoneal surgery as default in the surgical management of renal masses.

Patients and methods

At our institution, RP-RAPN is the preferred approach for treating patients with small renal masses. TP-RAPN is reserved for very anterior and hilar renal tumours. A prospective database of 784 RAPNs (2009–2020) was reviewed and 721 RRAPNs (92%) were performed at our centre We reviewed our prospectively maintained RAPN database at our institution. 557 patients underwent partial nephrectomies between June 2010 and April 2019. Of which, 517 cases were performed robotically. 468 (91%) patients underwent RP-RAPN.

Collected data included the patients' demographic, preoperative and peri-operative complications. We examined tumour characteristics and tumour complexity. Tumour complexity was classified according to R.E.N.A.L. nephrometry score: low (4–6), moderate (7–9) and high (10–12) [9]. Complications were graded based on the Clavien-Dindo classification system. The total operating time corresponds to time of port insertion, console time, and port skin closure.

We previously published our technique for retroperitoneal access for patients undergoing RAPN using da Vinci® Si HD Surgical System [10]. The patient is placed in the modified flank position. The operating table is fully flexed to increase the space between the iliac crest and 12th rib. A 12 mm incision is made 3.5 cm above iliac crest in mid-axillary line. A 12 mm PDB™ Auto Suture™ Round Shape Balloon (Covidien™, Mansfield, MA) is inserted and inflated to create the retroperitoneal space. The dilator device is exchanged for 12 mm Kii® Balloon Blunt Tip System (Applied Medical, Rancho Santa Margarita, CA). An 8 mm da Vinci® S port is inserted in the superior lumbar (Grynfelt-Lesshaft) triangle under direct vision. Another 8 mm da Vinci® S port is placed 8 cm from the camera port in the anterior axillary line cephalad to anterior superior iliac spine. A 12 mm Airseal® Access port (SurgiQuest, Milford, CT) is placed midway between the camera port and most medial robotic port (Fig. 1).

Our institution is a recognised national teaching centre for renal cancer surgery. Qualified fellows and residents are trained in a modular fashion to become independent robotic and laparoscopic renal surgeons upon completion of the fellowship programme. Subsequent outcome data, therefore, reflects the learning curves of several surgeons in adopting this technique and approach.

Statistical analysis and survival curve construction were performed using SPSS v27.

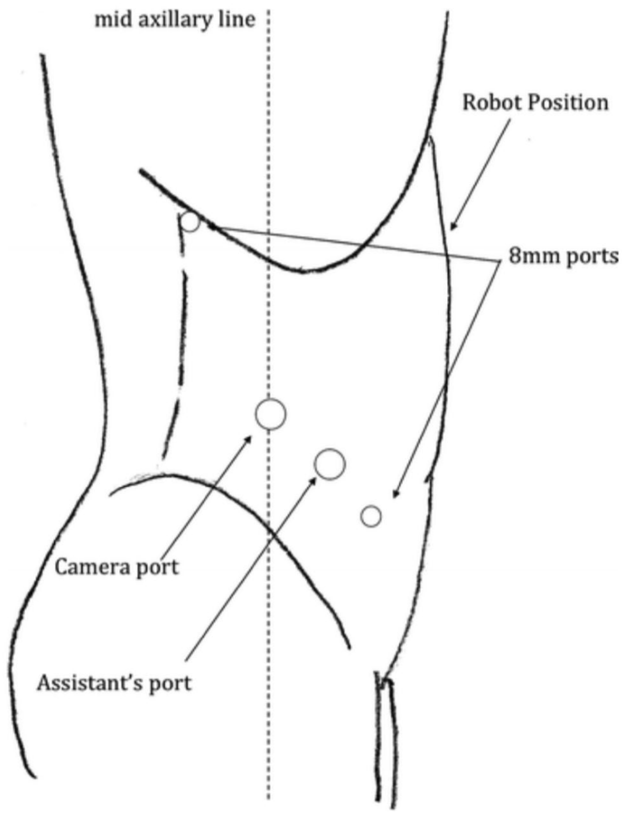

Fig. 1 Port positioning for RP-RAPN

Results

Demographics and lesion characteristics

To date a total of 800 patients have undergone RAPN, however in the interest of follow-up only the first 784 patients have been included in this study. Table 1 summaries the salient results of our study. Our cohort's mean age ± S.D of 60 ± 11 years (range 17–80 years) and were predominantly male (68%). They had a mean BMI ± S.D of 28.6 ± 5.7 (range 16.7–56.1) and a median American Society of Anesthesiologists (ASA) score of 2. Of 112 (14%) cases who underwent RAPN for imperative indications, 105 patients (13%) had pre-existing CKD stage 3/ > , with 26 patients having an eGFR < 45.

Our mean lesion size was 3.1 cm (range 0.7 cm– 10.5 cm) on pathological specimen processing, with a mean RENAL score of 6. Following RENAL risk stratification, 47% of patients had intermediate or highly complex lesions (RENAL scores 7/ >). Pre-operative biopsy was utilized in 5.7% of the cases. Forty-six lesions were in a hilar location, with just over 30% of cases located anteriorly. The transperitoneal route at our centre is utilized for carefully selected lesions in an anterior hilar location, where we feel the RP route may not be advantageous.

Operative characteristics and complications

Our centre favours the retroperitoneal approach to RAPN, with a mean operating time ± SD of 135 ± 43 min. Our mean WIT ± SD was 21 ± 7 min, and our median blood loss was 30mls. We utilize main arterial clamping as standard, and just over a third of cases undergo early off-clamping. There was a total of 23 conversions to radical nephrectomy (2.9%), of which 8 were open conversions (1%). All open conversions were pre-operatively planned or expected. Of the remainder, 53% of radical nephrectomy were for bleeding, with the remainder for tumour factors (possibility of transitional cell carcinoma, tumour rupture or risk of rupture).

Our overall intraoperative complication rate was 2%. Our median length of stay was 1 night (range 1- 50), with 84% of patient's discharged within 2 days of surgery (Fig. 2). Our overall post-operative complication rate was 7%; 38% of these were Clavien 3 or higher in severity.

Pathology and outcome

Eighty one percent of lesions were malignant, with 631 renal cancers present. Clear cell RCC was the predominant histological subtype (70%). Of the 19% benign histology in our cohort, oncocytoma were the commonest subtype (64%), followed by AMLs (26%). Most tumours were pT1a (77%). Of 147 RAPNs for pT1b/ > disease, a third of patients had pT3a disease on definitive histology due to microscopic fat invasion or segmental renal vein invasion. We encountered a positive surgical margin in 35 patients with an overall rate of 4.4%.

Over a mean 15 month follow-up period (range 1–125 months), 2% of patients developed recurrences and our cohort demonstrated a 99% 5-year cancer specific survival. There were 6 deaths attributable to renal malignancy (0.7%) in our series (outcomes determined by death certification), with a total of 21 deaths from all causes (2.6%).

We achieved a trifecta outcome in 67% of cases and a pentafecta outcome in 47% of cases. Multivariate analysis of our series demonstrated age ($p = 0.05$), operative time ($p = 0.008$), pT1b tumours ($p = 0.03$), R.E.N.A.L score and blood loss ($p = 0.001$) to statistically significantly influence achievement of trifecta. Pentafecta achievement was influenced by R.E.N.A.L score ($p = 0.008$), operative time ($p = 0.001$) and blood loss ($p = 0.001$).

Discussion

According to EAU and AUA guidelines, nephron-sparing surgery should be offered to patients with T1 renal masses. Thermal therapies are evolving; however good long-term quality data is currently lacking [1, 2]. We present our

Table 1 Demographics, Characteristics, Complications and Outcome summary

Demogrphics and Characteristics	No.	%/(range)	Complications and Outcomes	No.	%/(range)
Total No of Cases	784		Intraoperative Complications	16	2
Median Age	61	(17–80)	Bleeding/Vascular Injury	9	56
Female	251	32	Tumour Factors	6	38
Male	533	68	Arm Malfunction	1	6
Left	364	46			
Right	420	54	Post operative complications	52	6.6
Median BMI	27.8	(16.7–56.5)	Clavein 3/>	20	2.6
Median ASA	2	(1–3)	Pseudoaneurysm	6	0.9
Median eGFR	90	(23–90)	Pneumothorax	4	0.5
CKD 3/>	105	13	Urine Leak	3	0.4
Imperative Indication (Solitary Kidney, Bilateral Disease, CKD)	112	14	Sepsis	3	0.4
			Ileus	3	0.4
Mean Tumour Size (cm)	3.1 cm	(0.8 cm–10.5 cm)	AKI (filtered)	1	0.1
No. > 4 cm	166	21			
No. > 7 cm	10	1.3	30 day readmissions	19	2.4
Median RENAL Nephrometry Score	6	(4–11)	Median Length of Stay (days)	1	(1–50)
Low RENAL Complexity (< 6)	415	53			
Intermediate RENAL Complexity (7–9)	326	42			
High RENAL Complexity (10 >)	43	5			
Location					
Anterior	244	31	Stage		
Posterior	317	40	T1a	484	77
Neither	147	19	T1b	88	14
Hilar Location	76	10	T2	10	1.6
			T3a	49	7.8
Renal Sinus Involvement	49	6			
			Grade		
Pre-op Biopsy	45	5.7	G1–G2	398	63
			G3–G4	233	37
Technique					
Retroperitoneal	721	92	Positive Surgical Margin	35	4.4
Transperitoneal	63	8			
			Mean Follow-up (months)	15	(1–125)
Open Conversions	8	1			
			Recurrance	15	2
Median Operative Time (mins)	130	(42–330)	Mean time to recurrance (months)	21.4	(1.8 – 52.8)
Median Blood Loss (mls)	30	(0–3000)	Deaths	21	3
Intraoperative/Postoperative Transfusion	13	1.6	Cancer Specific	6	0.9
Selective Clamping	0		Trifecta Achievement	424	67
Median Warm Ischaemic Time (mins)	21	(0–60)	Pentafecta Achievement	310	49

experience of RP-RAPN that spans over a decade, at a tertiary referral centre in the UK, in achieving both good oncological and functional outcomes for our patients. Our PSM rate of 4.4% is in line with the existing literature, with a recurrence rate of 2% and 5-year cancer specific survival rates of 99%.

The choice of operative approach when tackling partial nephrectomy tends to be surgeon dependent. Naturally, higher volume centres are more likely to utilize and adopt RP-RAPN [11]. Based off the advantages and dis-9advantages of RP and TP surgery, there does seem to be a consensus in the literature when it comes to the recommended approach to use in partial nephrectomy, which is

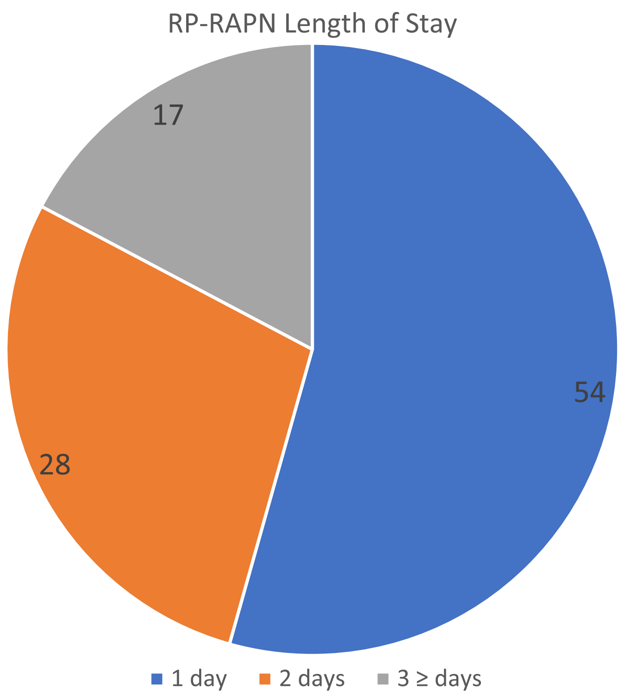

Fig. 2 Breakdown of inpatient length of stay (days) post RP-RAPN

summarized in Table 2 [7]. Our centre is unique in that RP-RAPN is our default approach to the management of renal masses, and this is (almost) irrespective of tumour location. Thirty percent of cases are anteriorly located tumours, and 3% of lesions managed through the RP route were anterior hilar (Table 1).

There are no randomized trials comparing the safety and efficacy of RP and TP RAPN. Most studies are retrospective in design and are confounded by selection bias. Our experience with the prominent literature on RP-RAPN is that it appears to be low volume data from centres that specialize predominantly in transperitoneal surgery who utilize this approach in favourable clinical circumstances. Table 3 highlights the key papers in the RP vs TP-RAPN debate, and we have focussed on the salient peri-operative, functional, and oncological outcomes of the retroperitoneal cohort and compared them to our own data from this study.

Across various studies comparing the two approaches, no consistent difference is identified between either route when it comes to peri-operative and oncological safety. Two meta-analysis studies showed no difference in major complications and conversion between RP-RAPN and TP-RAPN ($p=0.65$, $p=0.82$ respectively). These findings were in line with our study [23, 24]. Oncologically no significant difference in recurrence and disease progression is demonstrated in the literature. Similarly, no significant difference in eGFR decline in the immediate or longer term is recognized between the two approaches [5, 6, 13–21]. Another multicentre study from the transatlantic robotic nephron-sparing surgery study group showed no significant difference in terms of positive margins ($p=0.252$) [25], a finding confirmed at systematic review ($p=0.95$) [24]. Our own data would be consistent with this.

Where RP-RAPN does stand out however is when it comes to blood loss, inpatient stay and patient convalescence. There are consistent findings in the literature of significantly lower blood loss, shorter operative time, reduced median length of stay and faster return to normal activity (Table 3). A systematic review and meta-analysis of four eligible studies compared 229 TP-RAPN patients to 220 RP-RAPN patients who shared similar size, location and complexity characteristics. A significant difference in operative time was noted ($p=0.05$), with a mean difference of 28.03 min in favour of RP-RAPN [23]. Choo et al. demonstrated that this significant difference was present when both techniques were match-paired with nephrometry scores. Although no difference was found in the WIT ($p=0.139$), a statistically significant ($p=0.028$) mean 33 min reduction in operative time in favour of the RP group was noted even when match-paired for tumour complexity [13]. The message is much clearer regarding patient length of stay (LOS). LOS has been shown to be significantly shorter in RP-RAPN with a 1-day reduction in median LOS ($p=<0.0001$) in European collaborative data [11], and 2-day reduction in LOS ($p<0.01$) in International collaborations [26]. Our

Table 2 Summary of current consensus when considering the surgical approach to RAPN

RP-RAPN	TP-RAPN
Posterior and Lateral Renal Masses	Anterior and Medial Masses
Prior abdominal surgery	Highly Complex Tumours
Prior intraperitoneal pathology (e.g. Crohn's disease, Acute Abdomen, Ascites, Malignancy)	Anatomical Kidney Variations (Horseshoe, Pelvic)
	Obese patients
	Prior retroperitoneal/percutaneous renal procedures
	Prominent Iliac Crest/Lumbar Spine pathology limiting flexion

Table 3 Comparison of high-volume RP-RAPN series in the current literature

Author	RP- RAPN	Tumour Size (cm)	Nephrometry Score	Op Time (mins)	WIT (mins)	Complications (%)	Hospital Stay (days)	Positive Margins (%)	Drop in GFR
Hughes- Hallett, 2013 [6]	44	2.8	5.5	149	22	9	2.5	6.8	–
Gin, 2014 [12]	75	2.5	8	156	24	9	1.5	8	2
Choo, 2014 [13]	43	2.8	6	120	23	–	–	0	11.4
Kim, 2015 [14]	116	2.5	8	152	NR	7	1 d 57%	–	–
Sharma, 2016 [15]	25	–	7	224	27	16	2.3	4	–
Maurice, 2017 [16]	74	2.4	8	176	21	12	2.2	1.4	Statistically insignificant
Stroup, 2017 [17]	141	2.9	7	217	23	11	2.2	2.8	6.2
Laviana, 2018 [18]	78	–	–	167	21	24	1.8	3.9	4
Arora, 2018 [19]	99	3	7	160	17	–	1	2.1	6.8
Harke, 2019 [20]	203	2.6	9	120	8	14	8	4	6.4
Paulucci, 2019 [21]	157	2.9	–	157	17	12	1	3.9	–
Abaza, 2020 [5]	30	3.0	7	128	11	4 (overall)	0.7	0	16.3
Mittakanti, 2020 [22]	166	3.1	6	162	18	53	1.7	2.8	4.1
Frimley Renal Cancer Centre, 2021	**631**	**3.1**	**6.5**	**135**	**21**	**8**	**1**	**4**	**6**

*Bold signifies our centers data in comparison to other high volume retroperitoneal series in the literature own median length of stay is 1 day, with 84% of patients discharged within 2 days of surgery (Fig. 2).

Ultimately the choice of approach should be based on the surgeon's experience and expertise. Given a well-established practice, familiarity and higher volume there is evidence in the literature that TP-RAPN can be utilised safely and effectively to manage patients with posterior and lateral masses and in the 'hostile' abdomen [7, 16, 21, 27]. Criticisms aimed at RP-RAPN stem from low volume single centre experiences where there can be a tendency towards higher PSM rates for RP-RAPN patients and potentially worse oncological outcomes. This highlights the need for centralisation and high volume to achieve equivalent safety and efficacy in an otherwise unfamiliar operative environment [5]. To the best of our knowledge ours is the largest volume of RP-RAPN reported by a single centre (Table 3); over three times higher than some of the largest collaborative data available in contemporary literature. Our perioperative and oncological outcomes are equivalent to current TP series, whilst highlighting the key benefits of RP surgery in metrics such as blood loss, operative time, length of stay and patient convalescence. In our own experience with high-volume RP-RAPN we demonstrate similar safety and efficacy to RP-RAPN in cases where traditionally the TP route may have been favoured. Malki et al. have demonstrated the non-inferiority of RP-RAPN in obese patients [10]. Contemporary multicentre studies have demonstrated feasibility and safety of RP-RAPN in anterior, medial and complex tumours, whilst maintaining their advantages of shorter operative times and quicker patient convalescence [5, 11, 19, 20], and we would echo this sentiment.

The high surgical volume at our institution may, however, limit the transferability of our findings to lower volume centres and less experienced surgeons, which stresses the importance of centralisation and standardised training for those looking to learn and implement this approach in the practice.

Conclusion

This study reports the largest single institution experience of RP-RAPN described in the literature. Our data supports the premise that RP-RAPN is a safe and effective procedure and can be employed in most cases and, therefore, a strong case can be made for this to be the default approach for RAPN. Compared to the more commonly performed TP-RAPN, it is associated with less blood loss, shorter operative time and early discharge from hospital. The clinical and oncological relevance of these advantages are open to discussion.

However, with ever increasing pressures on global healthcare systems secondary to effects of the pandemic and preexisting supply and demand crises, the message of being able to do more cases (shorter operative time), discharge patients quicker (steady flow of elective operating) and achieve quicker patient convalescence (theoretically quicker return to normal activity and work) is certainly one that should resonate on a global scale.

Patient summary

This study is the largest series exploring an alternative approach to performing partial nephrectomy for kidney cancer that shows faster surgery, shorter hospital stay, quicker recovery and return to normal function whilst maintaining a high standard of functional and cancer outcomes.

Author contributions DS Wrote manuscript DS/SS/HNR/JO/MK - data collection/review MM, NB, AE, MH Concept, Design, Surgery, Review All authors reviewed manuscript.

Data Availability Data is available on request.

Declarations

Conflict of interest The authors declare no competing interests.

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