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REVIEW

# The effectiveness of ureteric metal stents in malignant ureteric obstructions: A systematic review

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**KEYWORDS**

Stent;
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**ABBREVIATIONS**

MS, metal stent;
PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses

**Abstract** ***Objective:*** To review the literature on the effectiveness, safety and long-term patency of ureteric metal mesh stents (MSs), as a variety of MSs have been used for managing malignant ureteric obstruction over the last three decades.

***Materials and methods:*** A systematic review using the search string; Ureter* AND (stent OR endoprosthesis) AND metal* was conducted on PubMed, Scopus, Web of science and Cochrane Library online databases in May 2016. Prospective, retrospective, and comparative studies including MSs were included. The primary endpoint was the patency rate and the secondary endpoint was complications.

***Results:*** In all, 324 publications were screened and 31 articles were included in the systematic review; 21 prospective and 10 retrospective studies. These studies reported the effectiveness of specific MSs in population studies, in comparative studies among different MSs, as well as among MSs and JJ stents. It should be noted that all comparative studies were retrospective.

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***Conclusion:*** The experiences with vascular MSs, such as the Wallstent™ (Boston Scientific/Microvasive, Natick, MA, USA), were related to high occlusion rates, due to endoluminal hyperplasia, and long-term disappointing patency. The use of covered MSs designed for the vascular system was also unfavourable. The Memokath 051™ (PNN Medical A/S, Kvistgaard, Denmark) had better patency rates, but also higher migration rates. The long-term results were acceptable and rendered the Memokath 051 as a viable option for the management of malignant ureteric obstruction. The Uventa™ (Taewoong Medical, Seoul, Korea) and Allium™ (Allium Medical Solutions Ltd, Caesarea, Israel) MSs, specifically designed for ureteric placement, provided promising results. Nevertheless, the wide acceptance of these MSs would require well-designed clinical studies and long-term follow-up.



## Introduction

Advanced malignant diseases can cause obstruction of the ureter and hydronephrosis with renal function impairment. Obstruction may be caused either by extension of the disease or by the extrinsic compression of the tumour on the ureter. The decompression of the ureter preserves renal function and prevents the consequences of the obstruction [1,2].

The first-line treatment is decompression of the obstruction either with percutaneous nephrostomy or with a JJ stent. These interventions are relatively easy and safe, and result in immediate renal decompression and function improvement. Nevertheless, their use is accompanied by several complications and disadvantages. Complications include haematuria, flank or abdominal pain, encrustation, UTIs, sepsis, and VUR. High rates of migration, decreased peristalsis of the ureter and relative obstruction, the possibility of loss of patency due to the extrinsic pressure, and the need for frequent replacements, are some of the disadvantages [1,2].

Patients with advanced malignant disease have a short life-expectancy and the quality of life should be taken into consideration when establishing a management plan. Frequent changes of JJ stents or the placement of a permanent nephrostomy have been related to deterioration in the quality of life of these patients [1]. In an attempt to avoid the frequent replacement of JJ stents or the insertion of permanent nephrostomies led to the introduction of metal mesh stents (MSs) in urological practice. Interventional cardiology and radiology have extensive experience in the use of MSs for maintaining the patency of vessels and the initial urological application was based on vascular MSs used in the ureter. This off-label use of vascular MSs in the ureter was associated with significant complications, e.g. tissue ingrowth, encrustation, and infection [3]. These complications could be attributed to the special histology of the urothelium and presence of urine and bacteria in the ureteric lumen. Nevertheless, a variety of MSs have been used for the management of malignant ureteric obstruction over the three decades [3]. In the present review, we evaluated the literature for the effectiveness, safety and long-term patency of ureteric MSs in the case of malignant ureteric obstruction.

## Literature search

A systematic review using the search string; ureter* AND (stent OR endoprosthesis) AND metal* was conducted on PubMed, Scopus, Web of science, and Cochrane Library online databases in May 2016. Prospective, retrospective, and comparative studies, including MSs were included. The languages of the articles were restricted to European languages including: English, French, German, Italian, Spanish, Greek, Portuguese, and Swedish. The eligibility criteria are presented in Table 1. The primary endpoint was the patency rate and the secondary endpoint was complications. The systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [4] (Fig. 1).

## Results

After excluding duplicate articles, two authors (D.K., P. K.) independently screened 326 publications by title and

**Table 1** Eligibility criteria of the systematic review.

| Eligibility criteria |
|---|
| - Adult patients with malignant extrinsic ureteric obstruction |
| -MS insertion in the ureter for ureteric obstruction alleviation |
| -Prospective or retrospective clinical studies |
| -Comparative studies of MS with other stent types |
| -Patency rate (primary endpoint) |
| -Complication rate (encrustation, infection, re-stenosis due to hyperplasia) |
| -European languages (English, French, German, Italian, Spanish, Greek, Portuguese, Swedish) |

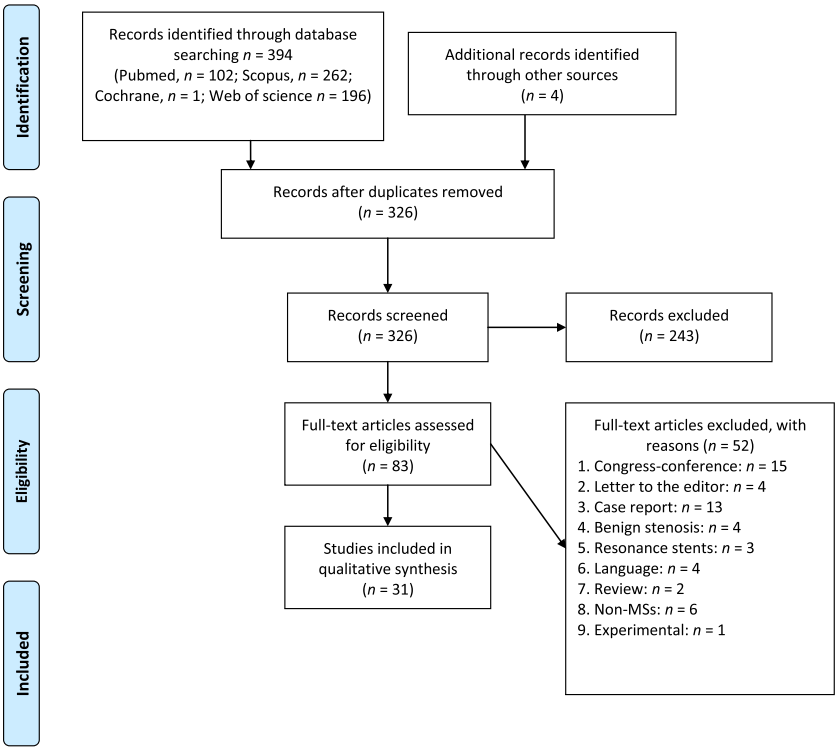


**Fig. 1** Flow-chart of the systematic review according to the PRISMA statement.

abstract resulting in 83 publications. These articles were assessed by their full text and 31 articles were eventually included in the systematic review. Any disagreements during the above process were resolved by consensus of these two authors and the involvement of a senior author (A.P.). Tables 2 and 3 summarise the included studies. The studies were published over a period of 23 years (1992–2016) and included 21 prospective and 10 retrospective studies. These studies reported the effectiveness of specific MSs in population studies [1–3,5–27], in comparative studies between different MSs [28] and between MSs and JJ stents [29,30]. It should be noted that all comparative studies were retrospective in nature.

The initial experiences with MSs in the ureter were based on vascular stents. The most commonly reported MSs used in the ureter for the management of malignant ureteric obstruction were the Wallstent™ (Boston Scientific/Microvasive, Natick, MA, USA), the Memokath 051™ (PNN Medical A/S, Kvistgaard, Denmark), the Uventa™ (Taewoong Medical, Seoul, Korea), and the Allium™ (Allium Medical Solutions Ltd, Caesarea, Israel). Tables 2 and 3 summarise the results for the primary and secondary endpoints. Wallstents were related to low patency rates (29–100% during a maximum follow-up of 140 months) due to lumen occlusion caused by hyperplasia or tumour expansion. The patency rates of Passager MSs (Boston Scientific) were low (18.8% during a mean follow-up of 8 months) and associated with high migration rates (81.2%) towards the bladder. The Memotherm MSs (Angiomed, Karlsruhe, Germany) had high patency rates (100% primary patency rates) and low rates of complications, but reports have not been published for a decade. The thermo-expandable Memokath 051 MSs achieved high patency rates (82–100%), but high migration rates (10.8–17.4%) were also reported. Finally, the Uventa MSs, specifically designed for the urinary tract, have been used in variable sizes with high patency rates (64.8–100%). The Allium covered MSs also designed for ureteric use had high patency rates (86.9–100%) but need further studies and documentation.

## Discussion

### *Off-label use MSs designed for vascular use in malignant ureteric obstruction*

Wallstents were initially designed for vascular use and were the first MSs to be used in the ureter [6]. The stents are composed of braided cobalt-based monofilament. Their lumen was occluded due to either reactive hyperplasia of the ureteric wall or tumour expansion through the struts of the stent during the follow-up period. Thus, low patency rates were reported [3,9,12,15,17–20,23]. Nevertheless, these MSs had low rates of other complications, such as migration of the stent, infection, haematuria, and pain [3,15,16,18,23]. Lang et al. [15] reported patency rates at to be 76% at 3 months, 41% at 6 months, and 29% at 11 months. Similarly, Lugmayr et al. [20] reported a primary patency rate of 31% after

**Table 2** Comparison chart of eligible population studies.

| Study group | Journal and year | Patients (ureters) | Stent | Type of study | Follow up, months mean (range) or range | Patency rate | Complications |
|---|---|---|---|---|---|---|---|
| Pauer et al. [23] | J Urol 1992 | 12 (15) | Wallstent | P | 0.75–7.75 | 12/15 ureters | Haematuria $n = 1$, encrustation $n = 2$, tumour obstruction $n = 3$ |
| Lugmayr et al. [18] | AJR Am J Roentgenol 1992 | 23 (30) | Wallstent | P | 7.75 (0.75–18.75) | 83% after 30 weeks | Haematuria $n = 1$, Encrustation $n = 2$, obstruction due to uroepithelial thickening $n = 4$ |
| Flueckiger et al. [12] | Radiology 1993 | 10 (13) | Wallstent | P | 5.8 (3–14) | 7/13 ureters | Urothelial hyperplasia in the lumen 5/13Tumour ingrowth 1/13 |
| Lugmayr et al. [19] | Aktuelle Radiol 1994 | 31 (44) | Wallstent | P | 1–27 | 100% | Reversible thickening of the mucosa |
| Lugmayr et al. [20] | Radiology 1996 | 40 (54) 53 ureters were successfully managed | Wallstent | P | 10.5 (1–44) | Primary patency 51%, primary patency estimation at 12 months 31% | None major |
| Pauer et al. [20] | Urologe A 1996 | 65/67 | Wallstent ($n = 62$), Memotherm ($n = 3$) | R | 1–60 | Primary 55%, Assisted 45% | Encrustation $n = 2$, tumour in-growth $n = 17$, tumour overgrowth $n = 11$ |
| Diaz-Lucas et al. [11] | J Endourol 1997 | 8 (14) | Wallstent | P | 20.4 (1–52) | 50% stenosis to the proximal end after 1 month | Dysuria $n = 1$, tumour in-growth $n = 1$, epithelial obstruction $n = 1$ |
| Lopez-Martinez et al. [17] | J Urol 1997 | 8 (12) | Wallstent | P | 19.25 (1–48) | 100% at 12 months 60% at 24 months 67% at 36 months 100% at 48 months | Stent occlusion $n = 5$ |
| Lang et al. [15] | AJR 1998 | 11 (20) | Wallstent | P | Up to 48 | 76% at 3 months 41% at 6 months 29% at 11 months 6% at 19 months | Tumour in-growth $n = 6$, Trigone oedema due to protrusion in the bladder $n = 2$, Migration $n = 1$ |
| Barbalias et al. [7] | Eur Urol 2000 | 14 | Wallstent | P | 15 (9–24) | 1/14 at 6 months 1/14 at 12 months | Tumour in-growth $n = 1$ |
| Liatsikos et al. [3] | J Urol 2009 | 90 (119) | Wallstent ($n = 42$), Passager ($n = 14$), Protégé($n = 11$), Accuflex ($n = 10$) Sinus Flex ($n = 8$), Luminexx ($n = 5$) | R | 15 (8–38) | Overall primary patency 51.2%, Secondary patency 62.1% | Flank pain $n = 41$, irritative bladder symptoms $n = 5$, infection $n = 3$, encrustation $n = 6$, migration $n = 13$, mucous hyperplasia obstruction within 1 month $n = 17$ |
| Lang et al. [16] | J Endourol 2013 | 24 (43) | Wallstent | R | 4–140 | Primary patency 54% | Migration $n = 3$, encrustation $n = 3$, UTI $n = 5$, Self-limited haematuria, irritative bladder symptoms, hyperplastic reaction $n = 10$, tumour in- |

(*continued on next page*)

**Table 2** (*continued*)

| Study group | Journal and year | Patients (ureters) | Stent | Type of study | Follow up, months mean (range) or range | Patency rate | Complications |
|---|---|---|---|---|---|---|---|
| | | | | | | | growth $n = 4$ |
| Barbalias et al. [9] | J Urol 1997 | 12 (14) | Accuflex ($n = 6$)Strecker ($n = 6$) | R | 9 (8–16) | 11/14 ureters patent at 8 th to 16 th month of follow up | Haematuria $n = 2$, migration $n = 1$, mild flank pain $n = 12$, obstruction due to hyperplastic epithelium $n = 1$(Accuflex), tumour in-growth $n = 1$ (Strecker), local recurrence of primary tumour $n = 1$ (Accuflex) |
| Pandian et al. [21] | Br J Urol 1998 | 7 | Memotherm | P | 9 (4–13) | Not reported | Not reported |
| Tekin et al. [25] | Urology 2001 | 8 (9) | Memotherm | P | 9 (1–14) | 100% | Irritative bladder symptoms $n = 2$ |
| Trueba Arguinarena et al. [6] | J Urol 2004 | 20 (37) | Memotherm | P | 6–24 | Primary 100% | Migration $n = 4$, mucous hyperplasia $n = 5$, recurrent UTIs $n = 9$ |
| Sibert et al. [24] | Prog Urol 2007 | 12 (13) | Memotherm | P | 19 (range not reported) | 100% | No complications |
| Kulkarni et al. [2] | BJU Int 1999 | 15 (22) | Memokath 051 | P | 10.6 (2–21) | 100% | Migration $n = 3$, bladder irritation $n = 3$ |
| Kulkarni et al. [14] | J Urol 2001 | 28 (37) | Memokath 051 | P | 19.3 (3–35) | 35/37 ureters | Migration $n = 4$ |
| Agrawal et al. [5] | BJU Int 2009 | 55 (74) | Memokath 051 | P | 16 (4–98) | 14/74 ureters | Urine extravasation $n = 1$, poor thermo-expansion $n = 1$, equipment failure $n = 1$, migration $n = 1$, encrustation $n = 2$, fungal infection $n = 3$ |
| Papatsoris and Buchholz [22] | J Endourol 2010 | 73 (86)31 malignant strictures | Memokath 051 | P | 17.1 (1–55) | Overall 93% | Encrustation $n = 4$, infection $n = 6$, dislodgement $n = 13$ |
| Zaman et al. [26] | Urol Int 2011 | 37 (42) | Memokath 051 | P | 22 (5–60) | 40/42 ureters | Migration $n = 5$, infection $n = 3$, tumour in-growth $n = 2$ |
| Barbalias et al. [8] | Eur Urol 2002 | 16 (20) | Passager | P | 8 (6–16) | 3/16 patients in the first 8 months | Migration in the bladder $n = 13$ |
| Moskovitz et al. [27] | 2012 | 30 (38) | Allium | P | 1–63 | 100% no stent occlusion, 86.9% due to stent migration | Stent migration $n = 5$ |
| Kim JH et al. [13] | Korean J Urol 2012 | 18 (20) | Uventa | P | 7.3 (3–15) | 100% | Irritative bladder symptoms $n = 2$, mild lower abdominal pain $n = 2$, haematuria $n = 3$ |
| Chung kJ et al. [10] | J Endourol 2013 | 54 (71) | Uventa | R | 11 (1.25–28.6) | Primary 64.8% Overall 81.7% | Pain $n = 30$, Secondary migration $n = 2$, LUTS $n = 5$, acute pyelonephritis $n = 2$ |
| Kim KH et al. [1] | Urology 2015 | 40 (40) | Uventa | R | 8.57 (not reported) | 77.5% | Not reported |
| Kim MD et al. [31] | J Endourol 2016 | 44 (50) | Uventa | R | 30.9 (8.1–49) | 26.5% | Ureteric injuries $n = 9$, uretero-arterial fistula $n = 3$, uretero-enteric fistula $n = 3$, uretero-vaginal fistula $n = 1$, bleeding $n = 1$, stone encrustation $n = 2$, migration $n = 2$ |

P, prospective; R, retrospective.

**Table 3** Comparison chart of eligible comparative studies.

| Study group | Journal and year | Patients (ureters) | Stent type 1 (number of patients) | Stent type 2 (number of patients) | Type of study | Follow-up Mean (range), months | Patency rate, % | Complications |
|---|---|---|---|---|---|---|---|---|
| Maan et al. [30] | J Endourol 2010 | 41 (55) | Memokath 051 (18) | JJ (23) | R | Not reported | Memokath 051: 100<br>JJ: 74 | Memokath 051: urinary frequency 47%, urinary symptoms 5.6%, negative view of life 35.3%, short stent 5.5%, migration 11%<br>JJ: urinary frequency 70%, urinary symptoms 31.8%, negative view of life 66.7% |
| Kim KS et al. [28] | J Laparoendosc Adv Surg Tech A 2014 | 27 (both malignant and benign cases) | Memokath 051 (10) | Uventa (17) | R | Memokath: 13.6,<br>Uventa: 12 | Memokath 051: 42.9<br>Uventa: 82.4<br>(clinical success rates) | Memokath 051: stent migration $n = 6$, flank pain $n = 1$, acute pyelonephritis $n = 1$, tumour progression $n = 2$<br>Uventa: migration $n = 1$, mucosal hyperplasia $n = 2$, flank pain $n = 1$, acute pyelonephritis $n = 1$, gross haematuria $n = 1$ |
| Chung HH et al. [29] | Cardiovasc Intervent Radiol 2014 | 88 (114) | Uventa (42 ureters) | JJ (72 ureters) | R | 9.1 (1.1–28.4) | Uventa (primary patency) at:<br>1 month: 100<br>3 months: 94.5<br>6 months: 74.7<br>9 months: 70.3<br>12 months: 65.3<br>18 months: 65.3<br>24 months: 65.3<br>JJ (assisted primary patency) at:<br>1 month: 78.6<br>3 months: 75.1<br>6 months: 59.1<br>9 months: 48.7<br>12 months: 38.7<br>18 months: 37.8 | Uventa: Mild pain $n = 4$, haematuria $n = 3$, UTI $n = 4$, Migration $n = 1$<br>JJ: not reported |

R, retrospective.

12 months of follow-up in a study summarising their experience with the Wallstent. Liatsikos et al. [3] reported that early reactive hyperplasia in almost all stents led to 17 occlusions in 90 patients within the first month.

Protege MSs (Endovascular, Inc., Plymouth, MN, USA), nitinol alloy self-expandable stents, are also designed for endovascular use. Their use in the urinary tract was reported in a small number of patients (11), which does not allow for any solid conclusions [3].

The Passager MSs are covered MSs with shape-memory properties designed for endovascular use. These stents were evaluated by Barbalias et al. [8] in an attempt to reduce ureteric hyperplasia and subsequent stent occlusion in 16 patients with malignant ureteric obstruction, but they had high migration rates (81.2%) and low patency rates (18.8% during a mean follow-up of 8 months).

An extensive long-term experience with various vascular stents including a large number of Wallstents was reported by Liatsikos et al. [3]. Primary and secondary patency rates of 51.2% and 62.1% were reported during a mean (range) follow-up of 59 (35–80) months. The authors concluded that the use of vascular stents in the ureter was hampered by low long-term patency rates, despite the initial promising experience. Considering the above results, it is clear that the vascular stents were not efficient in the long-term management of malignant ureteric obstruction and to improve the results would require the development of stents specially designed for the urinary tract.

*MSs specially designed for ureteric use*

The Memotherm MSs is a nitinol stent designed for use in the urinary tract. Arguinarena et al. [6] reported a primary patency rate of 100% and low migration rate (10.8%) in a cohort of 20 patients (37 renal units). Mucosal hyperplasia was noted in 13.5% of the cases. Sibert et al. [24] described 100% primary patency and

no complications during a mean follow-up period of 19 months in a cohort of 12 patients (13 renal units). Other smaller studies with the same MS showed promising results, with high patency rates over short follow-up periods ranging from 1 to 14 months and from 4 to 13 months, respectively [21,25]. Complications included stent occlusion in two of seven patients and irritative bladder symptoms in two of eight patients. The Memotherm was introduced almost two decades ago, but the reported experience is limited to 47 patients with the follow-up limited to 24 months. For more than a decade there have been no reports on the use of the stent and solid conclusions therefore cannot be drawn.

The Memokath 051 is a thermo-expandable stent designed for urological use. It consists of an alloy of nickel and titanium, and has a spiral form to prevent occlusion through the coils of the stent lumen from reactive hyperplastic epithelium or tumour ingrowth [2,22]. It is MRI compatible and available in a variety of lengths. The Memokath 051 has the unique feature that it can expand when 50 mL of sterile water preheated to 50 °C is injected at the proximal end of the stent. When water with a temperature of 5 °C is injected, the stent softens and can be removed [2,22]. The experience with Memokath 051 use in the ureter has shown low rates of complications such as haematuria, pain, infections, and encrustation [5,22,26,30]. The Memokath 051 was reported to have patency rates ranging between 82% and 100%. The most common complication was stent migration, with an incidence ranging between 10.8% and 17.4% of the stented ureters [2,5,14,22,26,28,30]. The Memokath 051 is a stent that has been used and studied for many years, especially from 1999 to 2014 (Tables 2 and 3). Long-term results have been reported in a large series of patients by Papatsoris and Buchholz [22], who investigated 73 patients (86 ureters) with a mean (range) follow-up of 17.1 (1–55) months. They reported high overall patency and high migration rates. Similar results were described by Agrawal et al. [5] in a study with the longest follow-up of Memokath 051 stent cases. They reported a mean (range) follow-up of 16 (4–98) months for 74 stented ureters; of which 28 patients (36 ureters) had malignant ureteric obstruction. Successful alleviation was seen in 25 patients, whilst the failed cases were associated with suboptimal positioning (one patient) and equipment failure (three). Stent migration occurred in six of the 36 stents (16.6%) in the malignant cases. Tumour ingrowth was not noted, stent occlusion was related to encrustations in two cases (3.7%), and stent migration was the most common complication for the overall population. The incidence of stent-related symptoms of patients treated by Memokath 051 were compared to conventional JJ stents in a study including both malignant and benign ureteric strictures [30]. In all, 70 patients were managed by either a Memokath 051 or JJ stent. Of these patients, 41 responded to the survey of the investigators. Patients with JJ stents had a higher incidence of urinary frequency, urinary symptoms and a negative view of life in comparison to the patients that had the Memokath 051 stent. Stent migration occurred in 11% of the Memokath 051 cases, whilst there was no migration in any of the patients with JJ stents. The Memokath 051 proved to provide durable long-term relief of the ureteric obstruction with failures related mostly to stent migration. The long-term experience showed that the stent could be considered a viable option for cases of malignant ureteric obstruction.

*Recently introduced MSs specially designed for ureteric use*

The Uventa stent is a recently introduced device specifically designed for use in the ureter. It consists of a double layer of nickel titanium alloys and between the layers includes a cover of polytetrafluoroethylene in order to prevent stent migration and epithelium adhesions [10]. The full cover and the zig-zag form offer great plasticity to the stent. It is available in 6-, 8-, 10-, 12-cm lengths. The combination of plasticity and difference sizes allow for the better adaptation to the stricture to be treated. Studies with the stent showed promising results in terms of patency and migration [1,10,13,28,29]. Low rates of complications such as haematuria, infections, LUTS, encrustation, and pain were reported. Patency rates were reported to range between 64.8% and 100% of the stented ureters. Chung et al. [10] presented a primary stent success rate of 64.8% and overall success rate of 81.7% in 71 ureters. The mean (range) patient follow-up was 11 (1.25–28.6) months. The most common cause of recurrent obstruction was tumour progression beyond the ureteric segment treated with the stent. Controversially, Kim et al. [31] reported a 30% primary success rate, with stent migration and tumour ingrowth being the causes of high failure rates. They also described high rates of major complications such as uretero–arterial fistulae (6%), uretero–enteric fistulae (6%), uretero–vaginal fistulae (2%), uncontrollable bleeding (2%), and stone encrustation (4%). The Uventa has been evaluated in comparison to the Memokath 051 and conventional JJ stents [28,29]. The comparison with the Memokath 051 showed higher patency rates for the Uventa, with clinical success in 14/17 (82.4%) of the cases (42.9% for the Memokath 051) [28]. In all, 10 patients were managed with the Memokath 051 and 17 with the Uventa. Obstruction of the lumen due to mucosal hyperplasia occurred in two cases treated with the Uventa. Tumour progression and stent migration occurred in one of 17 and eight of 10 patients in the Uventa and Memokath 051 groups, respectively [28]. A multicentre study compared the effectiveness of the Uventa to JJ stents for the management of 32 patients with malignant ureteric obstruction (42 ureters) [29]. The former stent achieved high patency rates of: 100% at 1

month, 94.5% at 3 months, 74.7% at 6 months, 70.3% at 9 months, and 65.3% at 12, 18 and 24 months. The respective rates were lower for the JJ stent. Migration of the Uventa occurred in 2.3% of the cases with other complications including mild pain ($n = 4$), haematuria ($n = 3$), and UTI ($n = 4$). Additional procedures were performed in two cases of occluded Uventa stents. The above evidence shows that the Uventa is probably efficient in the management of malignant ureteric strictures. Nevertheless, studies with more patients would allow for the wider acceptance of the stent. Additional randomised comparative studies would elucidate the advantages of the stent over other available stent options.

The Allium is a covered MS specifically designed for the ureter. The self-expanding metal component of the stent is made of nickel-titanium alloy nitinol and is covered by a biocompatible polymer. The latter cover does not allow the ingrowth of tissue through the stent struts and prevents early encrustation. The stent design allows for the unravelling of the metal structure when the removal of the MS is deemed necessary. Clinical experience included 30 patients with 38 obstructed renal systems due to malignant disease [27]. The follow-up of these cases ranged between 1 and 63 months. Stent migration was encountered in five cases and the MSs were endoscopically removed. During the follow-up period, 13 patients died from their primary malignancy with a patent stent *in situ*. The Allium showed high patency rates (86.9%) and patients remained asymptomatic. Nevertheless, the wider acceptance of the Allium MS requires additional studies documenting its effectiveness and safety profile. Considering the above, it is clear that the MSs represent an option for the management of malignant ureteric obstruction with promising results, especially in the case of stents which have been designed specifically for the urinary tract (Memokath 051, Uventa and Allium).

### *The contribution of the current review to the literature*

The present review summarises the currently available experiences in the literature, in an attempt to evaluate the contribution and potential of MSs in the treatment of malignant ureteric obstructions. The present review was conducted systematically according to the recommendations of the PRISMA statement and all the MSs that have been reported to be used in malignant ureteric obstruction were included. Previous reviews on MSs in malignant ureteric obstruction did not include all the types of MSs, as the Uventa and Allium MSs were not included [32,33].

### *Limitations*

A limitation of the present review was the lack of evidence that could be compared in a standardised fashion. Multiple MSs may have been reported in the same patient population, the patient selection criteria and the reporting of outcomes in conjunction to the follow-up were significantly variable among the studies. Therefore, a meta-analysis could not be performed. In addition, studies comparing different MSs was very limited ($n = 1$).

### *Implications for research and practice*

The need for the management of the patients with malignant ureteric obstruction has led urological research to the use of drug-eluting MSs in the ureter. These stents have been used in vascular disease for several years and provide lower re-stenosis rates in comparison to the common MSs. The improvement of the outcome is based on the release of a cytostatic drug that inhibits neo-intimal hyperplasia, which is responsible for the re-stenosis in the case of vessels. The same concept was introduced to urology with *in vivo* experimental studies that showed an improved outcome in the case of drug-eluting MSs [34].

## Conclusions

MSs have been used in the ureter for more than two decades. The experiences with vascular MSs, such as the Wallstent, were associated with high occlusion rates due to endoluminal hyperplasia and the long-term patency was disappointing. The use of covered MSs designed for the vascular system was also unfavourable. The need for reliable long-term drainage of the urinary tract gave rise to improved stent designs for the urinary tract, such as the Memokath 051. The experience with the Memokath 051 was associated with higher patency rates, but also higher migration rates. However, the long-term results were acceptable making the Memokath 051 a viable option for the management of malignant ureteric obstruction. The Uventa stent is the most recently designed MS specifically for ureteric application. The first reports provide promising results. The Allium stent is another MS specifically designed for the ureter, which was associated with high patency and low complications rates. Nevertheless, the wide acceptance of the Uventa and the Allium requires further well-designed studies and long-term follow-up. The concept of drug-eluting stents should be also evaluated in the case of ureteric MSs.

## Conflict of interest

None.

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