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ORIGINAL PAPER

Size does matter: 1.5 Fr. stone baskets almost double irrigation flow during flexible ureteroscopy compared to 1.9 Fr. stone baskets

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Abstract With a new generation of flexible ureterorenoscopes, a new area in stone management is emerging. Limitation of vision with these new instruments is often caused by insufficient irrigation flow, especially when using instruments like stone baskets, resulting from partial obstruction of the working and irrigation channel with these instruments. Empirically, new available smaller stone baskets seem to dramatically improve irrigation and therefore vision in clinical use. The goal of this study was to show objective differences in basket diameters and flow rates in an in vitro setting. Diameters and irrigation flows in flexible ureterorenoscopes depending on different sizes of stone baskets (Fr. 1.5–1.7–1.9–2.2–2.4–3.0) and different deflections were measured. The measured diameter of the baskets varied within the first 20 cm and the true measured size varied from the manufacturer's specified size to a different extent. The new generation of 1.5 and 1.7 Fr. baskets improved irrigation flow, even compared to the smallest commonly used baskets, up to 68%. Interestingly, deflection did not influence irrigation flow. This study confirmed the subjective impression of inadequate description of relevant basket diameters as well as that of a significant improvement of irrigation flow with the newest generation of stone baskets with smaller diameters.

Keywords Urinary lithiasis · Flexible ureteroscopes · Endourology

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Introduction

Flexible ureterorenoscopy, especially in stone disease, is a widely used and emerging technique in endourology. A new generation of instruments with either double deflection of about 180° or single deflection of about 270° widens the spectrum of indications in everyday endourological practice. Especially in patients with small lower calyx calculi, new generation flexible ureterorenoscopy is an efficient treatment alternative to either SWL with its low stone free rates or (Mini-) PCNL with its higher morbidity.

However, despite technical improvements, there are some major drawbacks of the procedure. Investigations in scope deflection and also in irrigation have shown a limitation of deflection and vision due to the use of common stone baskets [1]. While using smaller baskets like 1.9 or 2.2 Fr. in the instruments, changes in scope deflection are only minor compared to larger baskets like 3 Fr., the partial obstruction of the small diameter working channel in all new generation scopes caused by the stone baskets is the reason for the decreased irrigation flow and handicaps vision even when using baskets as small as 1.9 Fr.

To our knowledge, neither irrigation flow in newly developed smaller nitinol baskets of 1.5 and 1.7 Fr. size, nor the influence of instrument deflection on irrigation has been investigated until now.

In this contribution we compared the irrigation flow of new smaller 1.5 and 1.7 Fr. stone baskets to the commonly used nitinol baskets starting at 1.9 Fr. in an in vitro setting in the straight, the 90° and the 180° deflected instrument. To avoid erroneous measurement caused by reinforced distal sheaths, like the Cook N-Circle, measurements were performed with the sheath 1 cm inside and 1 cm outside the ureteroscope.

Materials and methods

Six different sizes of stone baskets were calibrated by means of an outside micrometer gauge (FMS Feinmess, Suhl, Germany) at the tip, as well as 5 and 20 cm behind the tip. Each measurement was performed at two different, right angle shifted positions of the gauge, and average results were demonstrated in millimeters with two decimals. The millimeter values were converted into Fr. using the conversion '1 mm = 3 Fr.' and rounded to two decimals (Table 1).

As an example, for the new generation ureterorenoscopes, a Flex-X² scope 7.5 Fr. (Karl Storz, Tuttlingen, Germany) with a 3.6 Fr. working channel was used for all flow measurements. All applied instruments and baskets were unused.

A NaCl irrigation solution was connected with a standard transfer set (Fresenius Kabi AG, Bad Homburg, Germany) to the luer lock inflow of the ureterorenoscope. Irrigation inflow pressure was calibrated at 100 cm H_2O after fixating the instrument on a table in a horizontal position. Collecting the irrigation fluid in a calibrated cylinder, three precise 1-min trials were measured with a stopwatch for each setting (Fig. 1). The flowmetry was processed in the described technique with straight, 90° and 180° bent instrument in 1 min trials, and irrigation flow was documented.

The ureterorenoscope without an instrument in the working channel was calibrated, and after insertion of the test basket throughout the working channel with tip of the basket sheath (closed basket) 1 cm out and 1 cm inside the ureteroscope, the measurements of irrigation flow were performed.

Mean flow values from the three measurements of each setting were used for demonstration and statistical analysis. Flow values were compared dependent on the type of basket and each relative flow rate in 90° and 180° deflection was compared to that of the 0° position. JMP (SAS Inc.) software was used for statistical analysis using one-way Anova analyses and all pair Tukey–Kramer HSD as post hoc analyses.

Table 1 Diameters (Fr.) of tested baskets at the tip and 5 and 20 cm behind the tip

Manufacturer, type, Fr. size of the basket	Diameter at the tip	Diameter 5 cm from the tip	Diameter 20 cm from the tip
Sacred heart, Halo, 1.5 Fr.	1.63	1.63	1.63
Cook, Prototype, 1.7 Fr.	1.76	1.66	1.8
Boston scientific, Zero-Tip 1.9 Fr.	2.06	1.83	2.1
Cook, N-Circle, 2.2 Fr.	2.26	1.93	2.16
Boston scientific, Zero-Tip, 2.4 Fr.	2.6	2.3	2.5
Sacred heart, Vantage, 3 Fr.	3.13	3.13	3.16

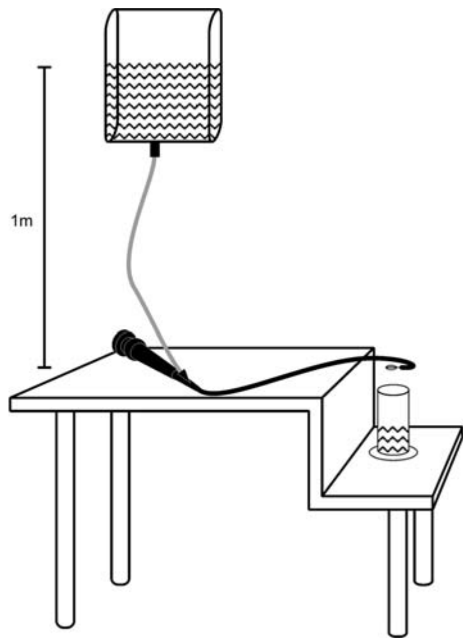

Fig. 1 Workbench with horizontal ureterorenoscope connected to the irrigation fluid (100 cm above the bench), collection of the irrigation fluid in a calibrated cylinder

Results

The true diameter of the baskets varied within the first 20 cm and the marketed size did not match up to the true measured size. As required by production tolerance, the true diameter was found always smaller than stated by the manufacturers, but to a different extent. Whereas most baskets (especially 5 cm from the tip) fall two digits below the manufacturer's specification, mainly the 1.5 Fr. basket provided a marginally smaller value than stated. The smallest diameters were measured with constant 0.49 mm at all three points (Sacred heart Halo 1.5 Fr.), whereas the smallest commonly used basket (Boston Scientific Zero-Tip 1.9 Fr.) measured 0.63 mm to 20 cm from the tip (Table 1).

The flow rates for the empty instrument channel as well as using each basket in 0°, 90° and 180° in both tips of the sheath inside and outside of the ureteroscope are presented in Table 2. Without any instrument in the working channel, there was a loss of 4 ml/min (8.0%) in irrigation flow at 180°. Using baskets, there was no relevant difference of irrigation flow at different basket positions detectable. Moreover, even depending on

Table 2 Irrigation flow characteristics with and without test baskets in the 0°, 90° and 180° deflected ureterorenoscope

Flex-X2 working channel 3.6 Fr.	Without basket	Sacred heart Vantage 3 Fr.	Boston scientific Zero Tip 2.4 Fr.	Cook N-Circle 2.2 Fr.	Boston scientific Zero Tip 1.9 Fr.	Cook Prototype 1.7 Fr.	Sacred heart Halo 1.5 Fr.
0° deflection (sheath inside)	50.00 (100.0%)	0.60 (1.2%)	3.50 (7.0%)	12.00 (24.0%)	14.00 (28.0%)	18.00 (36.0%)	20.00 (40.0%)
0° deflection (sheath outside)		0.55	3.50	14.00	12.50	17.00	21.00
90° deflection (sheath inside)	48.50 (100.0%)	0.55 (1.1%)	3.25 (6.7%)	12.00 (24.7%)	14.00 (28.9%)	18.00 (37.1%)	17.50 (36.1%)
90° deflection (sheath outside)		0.45	3.25	12.00	15.00	18.00	19.50
180° deflection (sheath inside)	46.00 (100.0%)	0.55 (1.2%)	3.00 (6.5%)	12.00 (26.1%)	15.00 (32.6%)	18.00 (39.1%)	20.00 (43.5%)
180° deflection (sheath outside)		0.50	3.25	12.00	14.00	18.00	20.00

Values are represented in ml/min and percentage from each 'without basket' situation are given within parentheses

scope deflection, there was no significant difference detected between 0°, 90° and 180° ($P = 0.5069$, Anova), but a clear change of irrigation flow depending on basket size could be observed. Whereas the base flow rate with the empty working channel was 50.00 and 46.00 ml/min in 0° and 180° deflection of the instrument, respectively, a progressive decrease of irrigation flow with increasing basket size was evident. With a 3.0 Fr. basket, the flow decreased by 49.40 (98.8%) and 45.45 (98.8%) ml/min in 0° and 180° deflection, respectively. With the 1.5 Fr. basket, the flow decreased only by 30.00 (60.0%) and 26.00 ml/min (56.5%) during 0° and 180° deflexion (Fig. 2).

The new 1.5 Fr. basket showed a significant improvement in flow rate in all degrees of deflection, even compared to the smallest available common nitinol baskets in 1.9 Fr. In the 0° position there was a difference of up to 8.50 ml/min compared to baskets with 1.9 Fr. in 180° deflection of 6.00 ml/min, an improvement of irrigation flow of 68.0 and 42.9%. Statistical analysis provided significant differences between all tested baskets ($P < 0.0001$, Anova, all levels significantly different in Tukey–Kramer) and showed a strict improved irrigation flow with decreasing diameter of the basket. Mean flow rates were 0.53 (95% KI 0–1.13), 3.29 (KI 2.69–3.89), 12.33 (KI 11.74–12.93), 14.08 (KI 13.49–14.68), 17.83 (KI 17.24–18.43) and 19.67 (KI 19.07–20.26) for 3, 2.4, 2.2, 1.9, 1.7 and 1.5 Fr., respectively. In Tukey–Kramer demonstration, a wider gap between the 2.4 and 2.2 Fr. and also between the 1.9 and 1.7 Fr was evident.

Discussion

Two major drawbacks of flexible ureterorenoscopy are decrease of instrument deflection and decrease of irrigation flow, both depending on the size of inserted stone baskets. Whereas the first problem could be overcome using small 1.9 or 2.2 Fr. nitinol baskets, resulting in almost unrecognizable worsening of deflection, decrease of irrigation and therefore bad vision is an unsolved problem in flexible ureterorenoscopy. Ames et al. [2] showed dramatically the decrease of irrigation in flexible ureterorenoscopy in a recent contribution. Canales and coworkers reported a superior flow rate of the Halo 1.5 Fr. basket compared to Cook 3 Fr. Laser Flat Wire and Microvasive 1.9 Fr. Zerotip baskets when used in combination with simultaneous laser lithotripsy alongside the basket in a recent video presentation [3]

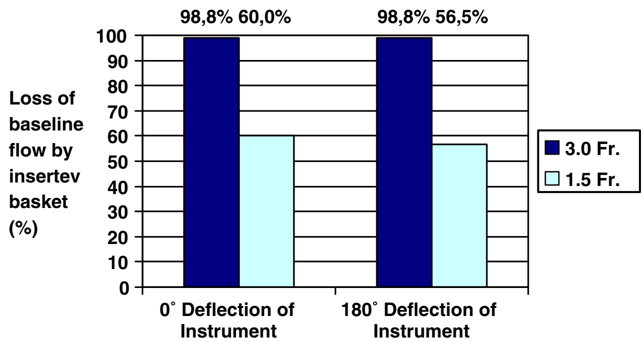

Fig. 2 Loss of irrigant flow in percentage of the baseline with applied 1.5 and 3.0 Fr. baskets in 0° and 180° deflection

In the present study, the deterioration of irrigant flow depending on basket diameter is confirmed. New baskets like the 1.5 Fr. Halo basket outperform 1.9 Fr. baskets in irrigation flow by 68.0% in straight and by 42.9% in the 180° deflected position, thus resulting in better endoscopic vision in cases of bleeding or caliceal debris. Despite an expected reduction of liquid flow in the bent position due to conceivable centrifugal forces perpendicular to the flow direction and continuous required changes in the linear momentum of the flow, deflection of the ureterorenoscope has only a minor impact on irrigation flow. Whenever possible, a small diameter basket should be used to have optimal vision and improve therapeutic efficacy of this minimally invasive procedure.

Conclusion

The smaller the stone basket is, the higher is the irrigation flow and therefore the vision. As could be shown in the present study, bending of the instrument has nearly no impact on irrigation, nor has the position of the sheath slightly inside or outside the instrument. New 1.5 or 1.7 Fr. stone baskets improve irrigation significantly compared to commonly used baskets, resulting in faster exchange of intrarenal fluid, thus resulting in better vision. Future studies are suggested to compare possible flow differences between baskets of "similar" size provided by different manufacturers.

References

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