

Durability of current generation flexible ureteroscopes: the experience from a high-volume centre

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Introduction The aim of this article was to evaluate the durability of current generation fibreoptic flexible ureteroscopes (FURS), analyse factors that influence durability, identify reasons for premature damage of FURS and offer suggestions to expand its life span.

Material and methods A total of 952 retrograde intrarenal surgeries (RIRS) done for upper tract calculi using 8 fibreoptic FURS, namely three Storz Flex X2, one Flex X2S, two Olympus URF- P6, two Olympus URF- P7, between March 2013 and December 2018, were reviewed retrospectively. All procedures were done by two consultants, in a single referral centre. Data relating to stone characteristics and flexible ureteroscopy procedure were retrieved from hospital database. The primary end point was damage of FURS requiring first repair.

Results The average stone burden was 14.59 ±3.37 mm (range 3–22 mm). Ureteral access sheath was used in 95.4% of cases, 36.7% of the cases were pre-stented. Mean ureteroscope durability was 119 procedures and mean ureteroscopy time was 71.99 hours of use before first repair. Prolonged laser usage time and increased usage of accessories had significant negative impact on longevity of FURS ($p = 0.002$, $p = 0.036$ respectively). Inadvertent laser fibre misfire and extreme torque caused premature FURS damage, at the end of 35 and 12 procedures respectively.

Conclusions Current generation fibreoptic flexible ureteroscopes have a mean durability of 119 procedures. Anticipation of torque, knowledge of the common reasons for damage and meticulous handling is essential to maximise the durability of FURS.

Key Words: flexible ureteroscope ↔ fibreoptic ↔ reusable ↔ premature damage ↔ durability

INTRODUCTION

Flexible ureteroscopy is becoming indispensable worldwide with the expanding diagnostic and therapeutic indications. It has been recommended as the standard of care for renal stones less than 2 cm by the European Association of Urology (EAU) [1] and the American Urological Association (AUA) [2]. The current generation flexible ureteroscopes have come up with numerous innovations such as improved optics, better ergonomics, reduction in both tip and shaft diameter, and better deflectability.

Despite the continued technological advancements, the flexible ureteroscopes (FURS) are still considered as fragile instruments. The substantial costs owing to the repair or replacement of the FURS is an important concern [3], especially in high volume centres. Maximising the durability and minimising the repair costs or replacement of scopes is the need of the hour.

Our primary aim is to analyse the durability of the current generation fibre-optic flexible ureteroscopes. Durability is defined as the number of flexible ureterorenoscopic procedures performed with each flexible ureteroscope until the first repair

is required [10]. The secondary aim is to analyse the factors that influence the durability of FURS, identify reasons for premature damage of FURS and offer suggestions to expand its life span. No comparison is aimed between the type or brand of the scope.

MATERIAL AND METHODS

Between March 2013 and December 2018, all retrograde intrarenal surgeries (RIRS) were performed using eight fibre-optic FURS, namely three Flex X2 (named Flex X2 A, Flex X2 B, and Flex X2 C for convenience), one Flex X2S (Karl Storz, Tuttlingen, Germany), two Olympus P6 (named P6 A and P6 B) and two Olympus P7 scopes (P7 A and P7 B) (Olympus, Shinjuku, Tokyo, Japan) were reviewed retrospectively. The flexible ureteroscopes were new at the start of the study. The primary endpoint was the FURS damage, until the first repair. Once it was damaged (for instance, loss of deflection lever, fibre-optic bundle damage, perforation of the working channel, breakage of the scope, etc.), the FURS was removed from the study and replaced by a new one. All flexible ureteroscopies were carried out by two experienced endourologists (CM and RK) in a single referral centre.

Proximal ureteral and renal calculi cases up to 25 mm sizes were included. Details of stone characteristics based on computed tomography of kidney ureter and bladder (CT KUB), presence of anatomic anomalies,

total ureteroscopy time and lower pole usage time, pre-stented status, access sheath usage, passage of accessories through working channel, laser time, and causes for damage of the scope were retrieved from the hospital database. Total ureteroscopy time was defined as the time taken from the passage of the ureteroscope into the external urethral meatus or ureteral access sheath (UAS) until removal of the scope from the system.

Operative technique

All procedures were carried out in a standard manner, beginning with the passage of a guidewire (Terumo, Somerset, New Jersey) followed by ureteroscopy (6/7.5 Fr semi-rigid ureteroscope - Richard Wolf, Germany) to assess the distensibility of the ureter and migrate proximal ureteral stones into the kidney. With the safety guidewire (0.018" terumo) by the side, ureteral access sheath (UAS) was placed in almost all the cases. A 9.5/11.5 Fr, 28 cm (Cook Flexor) access sheath was inserted over a 4/6.5 Fr semi-rigid ureteroscope or threaded over a 0.038" terumo guidewire under fluoroscopic guidance (only in pre-stented cases). Active ureteral dilatation was never attempted. Cases in which the access sheath insertion failed were stented and taken up for RIRS after a span of 10–14 days.

Laser fibre and basket were introduced after straightening the flexible segment almost always. Laser lithotripsy was performed using holmium laser,

Table 1. Demographic data and intraoperative parameters pertaining to each flexible ureteroscope

Parameters	Flex X2 A	Flex X2 B	Flex X2 C	Flex X2S	Olympus P6 A	Olympus P6 B	Olympus P7 A	Olympus P7 B
Total no. of renal units	152	126	183	165	87	192	12	35
Single stones	125	104	151	136	72	158	10	29
Multiple stones	27	22	32	29	15	34	2	6
≥1 cm	88	74	112	107	59	138	7	17
<1 cm	64	52	71	58	28	54	5	18
Lower calyx	55	32	45	40	25	46	3	10
In situ	27	14	15	8	7	21	1	3
Relocated	28	18	30	32	18	25	2	7
Pelvis	57	24	45	48	24	51	4	12
Upper calyx	51	42	36	60	15	72	3	6
Middle calyx	45	30	54	48	16	52	2	21
Upper ureter	63	18	36	63	36	48	–	9
Abnormal anatomy – Malrotation/ectopic/HS	12	8	4	5	3	2	–	–
Total no. of procedures	126	152	183	165	87	192	12	35
Total ureteroscopy time (total hours of usage)	96.13	77.71	110.3	101.4	50.8	112.3	7.21	19.8
Procedure duration (mean, min)	38.2	36.72	36.19	36.9	35.06	35.11	36.08	34.09

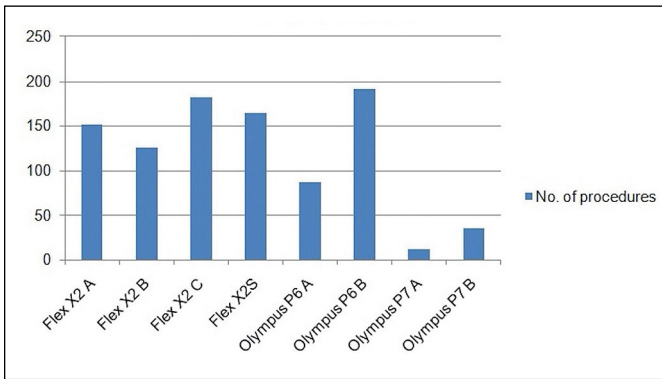


Figure 1. Total no. of procedures done with each FURS before first repair.

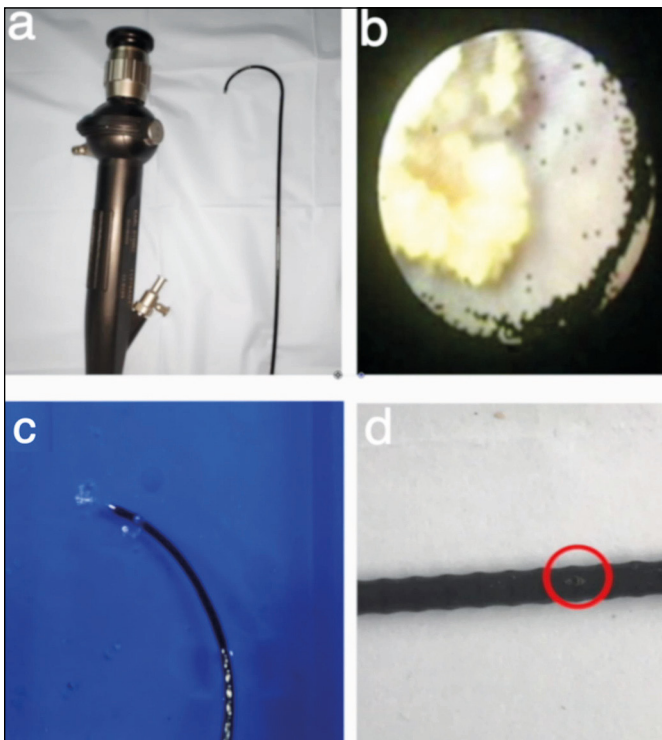


Figure 2a. Loss of deflection Lever, **b.** Fibre-optic bundle breaks, **c.** and **d.** Laser fibre induced perforation of working channel, positive leak test.

30 Watts (Quanta), 200-micron fibre. Initial contact lithotripsy was carried out using the settings of 5–15 Hz, 0.5–1.2 J, aiming dust. When painting was no longer possible, noncontact lithotripsy (popcorning) was conducted using 10–15 Hz and 1–1.5 J. Lower pole stones were relocated to the easily accessible calyx using a nitinol basket (N-circle 2.2 Fr, Cook Urological or Dakota 1.9 Fr, Boston Scientific) whenever possible. Impacted lower pole stones that were not amenable to basketing were fragmented in situ. Basketing to extract out the fragments was avoided

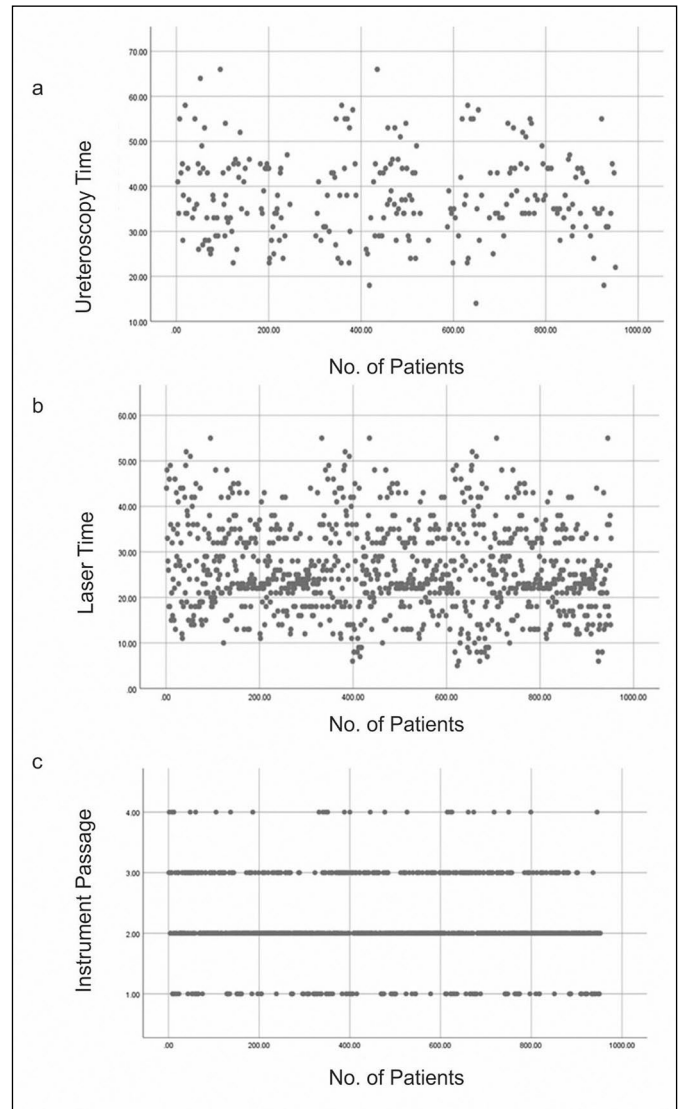


Figure 3a. Correlation of ureteroscopy time (Lower pole and anomalous kidney usage time) with durability, **b.** Correlation of Laser time with durability, **c.** Correlation of instrument (accessories) passage with durability.

and used only for obtaining samples for performing stone analysis in children.

After the procedure, the FURS were washed, cleaned, dried with pressurised air, and stored in the container, by dedicated staff. High level disinfection was carried out by complete immersion in disinfectant (2.4% glutaraldehyde – cidex) for a span of 45 minutes before the start of the procedure. The scopes were leak tested between uses.

Statistical analysis

The factors analysed were a) pre-stented status, b) lower pole and anomalous location ureterosco-

Table 2. Analysis of factors influencing the durability of the flexible ureteroscope

	Flex X2 A	Flex X2 B	Flex X2 C	Flex X2S	Olympus P6 A	Olympus P6 B	Olympus P7 A	Olympus P7 B	Correlation	P Value
Pre-stenting status (%)	57.6	64.4	58.4	69.4	64.5	67.1	55.5	51.8	0.212	0.993
Lower pole & anomalous anatomy usage time (total hours)	34.6	19.6	27.02	24.5	14.5	26.8	1.8	5.6	-0.014	0.823
Laser time (total hours)	70.8	56.4	79.97	73.9	36.78	80.68	5.25	14.76	-0.101	0.002
No. of passes of accessories through working channel	425	262	457	578	366	594	28	80	-0.068	0.036

py time (procedures with manual forcing), c) laser time, and d) accessories passage. Statistical analysis was performed using SPSS software, version 23. Chi-Square test and Pearson Correlation were used to analyse if any of these factors had a significant influence on the durability of the flexible ureteroscope.

RESULTS

952 retrograde intrarenal surgeries with laser lithotripsy were performed. There was no case of flexible ureterorenoscopy done for diagnostic purpose or for upper tract tumor. Out of the 952 procedures, 11.7% (n = 111) were carried out for proximal ureteral stones and 88.3% (n = 841) for renal stones. 82.5% (n = 785) procedures were done for single stones and 17.5% (n = 167) for multiple stones. The average stone burden was 14.59 ± 3.37 mm (3–22 mm). Lower pole stones were found in 26.9% (n = 256) of the cases and 62.1% (n = 160 out of 256 cases) of them were relocated to the easily accessible calyx, while the remaining were completed in situ. Anomalous kidneys were encountered in 3.57% (n = 34) of the cases. The stone characteristics are elaborated in Table 1.

The mean FURS durability was 119 procedures (Figure 1) and the mean flexible ureteroscopy time was 71.99 hours of use before the first repair. The mean procedure duration was 36.3 ± 9.98 mins (range 10–66 mins). UAS was used in 95.37% (n = 908) of the cases and 36.7% (n = 350) of the cases were pre-stented.

Out of the 8 FURS, 4 experienced gradual loss of deflection lever (Figure 2a). Extensive fibre-optic bundle damage precluding the use was encountered in two FURS (Figure 2b), one happened due to manual forcing while doing sheath-less RIRS and the other occurred during RIRS for inferior-anterior calyceal stone.

Two FURS were damaged prematurely – One was broken at the shaft-tip junction due to extreme

torque (after 12 procedures) and another had working channel perforation due to laser fibre misfire (after 35 procedures) while being used for a lower calyceal stone (Figures 2c and 2d).

Statistical analysis revealed that with the increase in laser usage time and frequent passage of accessories, the durability of the FURS decreased significantly (p = 0.002, p = 0.036 respectively) (Table 2). The lower pole usage time or the pre-stented status did not have a significant influence on the durability (p = 0.823, p = 0.993 respectively) (Figures 3a,b,c).

DISCUSSION

Owing to the continued technological advancements and improving surgeon experience, the durability of flexible ureteroscopes have improved. Due to the huge repair costs, durability becomes a critical component before investing heavily in reusable flexible ureteroscopes [4, 5, 12]. Borofsky and colleagues demonstrated that the majority of expenditure associated with owning a FURS was due to the repair of scopes (71%) [4]. Carey and colleagues pointed out that one instrument repair would further reduce its longevity, and therefore replacing it with a new scope would be cost effective [6]. Therefore, prolonging the durability of the scope is essential in order to be cost effective. We present the largest data on the current generation fibre-optic FURS, analysing the number of cases one would last before the first repair.

Pietrow et al (2002) demonstrated a longevity of 19–34 procedures using four new Olympus flexible ureteroscopes [7]. Monga et al. (2005) [8] presented data on seven different previous generation FURS, which required repair after around 3.25–14.4 procedures. Subsequently thereafter, till date, significant improvement in durability has been reported, parallel to the refinement in engineering and improvement in surgeon experience. Defidio and colleagues (2012) studied the durability of two Flex-X scopes. Their report revealed a mean durability of 107.5 procedures and a total ureteroscopy time of 75 hours

and 15 minutes [9]. Legemate et al. (2018) presented data on six FURS, out of which two were fibre-optic scopes. The two fibre-optic FURS lasted for a mean of 24 procedures (10–37) and 14 hours of use before major damage [10].

There is no report on the lifespan of current generation fibre optic FURS exclusively. Our analysis revealed a mean durability of 119 procedures and a mean FURS usage time of 71.99 hours before the first repair. In our series, the mean procedure duration was 36.3 minutes \pm 9.98 (range 10–66). Although this is much lower than that reported by other authors [9, 11], the total usage time is comparable. We attribute the shorter mean procedure duration to our technique of aiming complete dust and not basketing out fragments. The variation in the indication of flexible ureteroscopy, stone size, and composition are also contributory [9, 11]. Three of our FURS had the longest lifespan reported in literature so far (namely Flex X2S – 165 cases, Flex X2 C – 183 cases, and Olympus P6 B – 192 cases).

The use of UAS undoubtedly reduces the stress of flexible scope entry and re-entry, as emphasised by previous authors [7, 8, 11]. We had used access sheath in 95.38% of the cases, which probably has contributed to our higher mean durability. Defidio et al had used UAS in only 25% of the cases due to the practice of routine pre-procedural optical dilatation with 9.5Fr semi-rigid ureteroscope [9].

Marchini et al. [12] showed in his meta-analysis that lower pole pathologies, large stone burden, and non-usage of ureteral access sheath had a negative impact on device longevity. Knudsen et al. (2005) [13] pointed out the increased risk of laser fibre fracture due to heavy energy transmission in deflected position. Ozimek et al. [14] reported that the location of stones in the lower pole was not a significant factor causing FURS damage, but a steeper in fundibulopelvic angle, IPA (median 440) was. In our study, the total lower pole usage time was 19.30 hours (mean), which had no significant influence on the durability of the scope concerned ($p = 0.823$).

Shaft damage due to manual forcing was the most common reason for repair after a mean 24 procedures, as stated by Legemate and colleagues [10]. In our series, the loss of deflection mechanism was the most common cause of damage (4 out of 8 FURS) at the end of a mean 150.83 procedures. The fibre optic bundle damage was the second most common reason for loss of FURS. Two of our FURS were damaged prematurely due to extreme torque (P7 B – 12 cases) and inadvertent laser fibre misfire (P7 B – 35 cases).

McDougall et al. [15] compared the usage of Steris 20 (peroxyacetic acid 35%) with Cidex (2.4% glutaraldehyde) and found that neither of these had

an effect on the durability of the flexible ureteroscope. Abraham et al. [16] observed in his study that the scopes sterilized using Steris 1 (1 (peroxyacetic acid 35%; 30 mins cycle at 50–56°C) had reduced durability compared to those disinfected by 2.4% glutaraldehyde. Semins et al demonstrated that the handling of instruments by trained staff had prolonged the time to repair, rather than the method of sterilisation [17]. In our series, we had used 2.4% glutaraldehyde and there was no case of damage to the ureteroscope shaft.

Knudsen et al. [13], in his study on the 4 flexible ureteroscopes of the previous generation, had reported early catastrophic failure in Gyrus-ACMI DUR-8 Elite, due to laser fibre misfire in the working channel. In our series, two Olympus P7 scopes were damaged prematurely, one due to extreme manual forcing and the other due to laser fibre misfire.

Our study has shown the highest durability (mean 119) with current generation fibre-optic FURS reported in literature till date. Our study has shown the highest durability (mean 119) with current generation fibre-optic FURS reported in literature till date. We suggest the following to expand the lifespan of a flexible ureteroscope: routine pre-procedural ureteroscopy to assess the distensibility of ureter and usage of ureteral access sheath whenever possible, avoiding introduction of accessories in deflected position, avoiding prolonged maintenance of active deflection, early relocation to easily accessible calyx (upper/middle), keeping laser fibre at a safe distance from the tip of the flexible ureteroscope, avoiding inadvertent activation of laser unless the fibre is clearly visible on the screen, aiming for complete dust, and avoiding frequent insertion of basket to retrieve fragments. Training and allocating dedicated staff for the care of FURS also plays an important role.

Strengths of our study: 1. Largest data focused exclusively on the fibre-optic flexible ureteroscopes of the current generation, and 2. Uniform indication for flexible ureteroscopy (stones).

However, limitations of the study include the retrospective nature, failure to include repaired/refurbished scopes in the study, as this would have provided a better and complete understanding on the true life span of the flexible ureteroscope. Also, certain factors like stone volume, composition, and infundibulopelvic angle have not been analysed, which also may have an effect on the durability. Additionally, the cost of purchase of a new scope in comparison with repair of the scope could not be analysed as the refurbished scopes were excluded from the study. Further studies in this regard are warranted to have a concrete understanding of the factors that influence the durability of the scope.

CONCLUSIONS

The current generation fibre-optic flexible ureteroscopes are quite durable (with a mean of 119 procedures per flexible ureteroscope). Prolonged laser usage time and frequent usage of accessories are risk factors for FURS damage. Accidental laser perforation and extreme manual forcing can cause premature damage of the scope. Anticipation of torque, knowledge of the common reasons for damage, and cautious handling is essential to extend the longevity of FURS.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICS APPROVAL

Ethical committee approval sought, but waived off by Our Institutional Ethics Committee, in view of retrospective nature of the study and all the procedures that were performed were part of the routine care.

AUTHORS' CONTRIBUTION

Chandramohan Vaddi: project development, data collection, manuscript writing

Ramakrishna Paidakula: data collection, manuscript editing

Soundarya Ganesan: data collection, data analysis, manuscript writing

Siddalinga Swamy PM: manuscript editing

Hemnath Anandan: manuscript editing

Manas Babu: manuscript editing

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