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In Vitro and In Vivo Comparison of Optics and Performance of a Distal Sensor Ureteroscope (Storz Flex-X^C) vs. a Standard Fiberoptic Ureteroscope (Storz Flex-X^2)

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Introduction: Recent advances in distal sensor technologies have made distal sensor ureteroscopes both commercially and technically feasible. We evaluated the performance characteristics and optics of a new generation distal sensor (Flex-X^C, Karl Storz, Tuttlingen, Germany)(X^c) and a standard flexible fiberoptic ureteroscope (Flex-X^2, Karl Storz, Tuttlingen, Germany)(X^2).

Methods: The two ureteroscopes were compared for active deflection, irrigation flow rates and optical characteristics. Each ureteroscope was evaluated with an empty working channel and with various accessories. Optical characteristics (resolution, grayscale imaging and color representation) were measured using USAF test targets. The ureteroscopes were tested *in vivo* in a porcine model using a HD monitor and an HD recording system. We digitally recorded a renal porcine ureteroscopy and laser ablation of a stone with the X^2 and with the X^C. Edited footage of the recorded procedure was shown to different surgeons (n=8) on a HD monitor for evaluation by questionnaire for image quality and performance.

Figures:

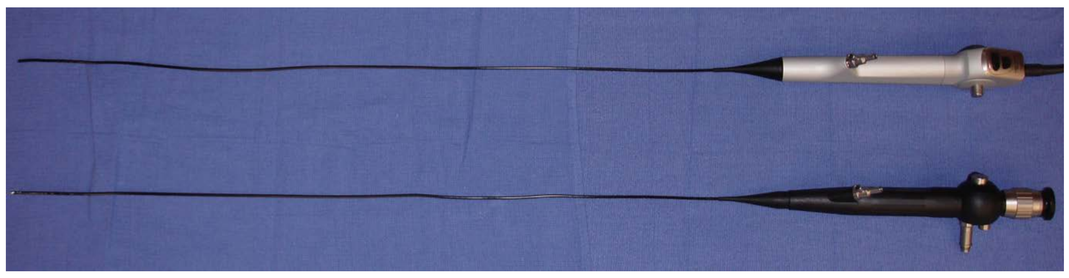

Figure 1: Storz flexible ureteroscope X^C and X^2

Figure 2: Comparision distal tip design X^2 (left) and X^C (right)

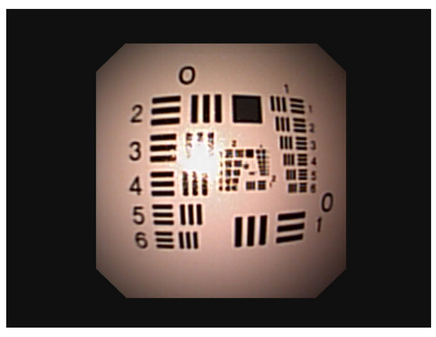

Figure 3: USAF 1951 resolution target - X^C

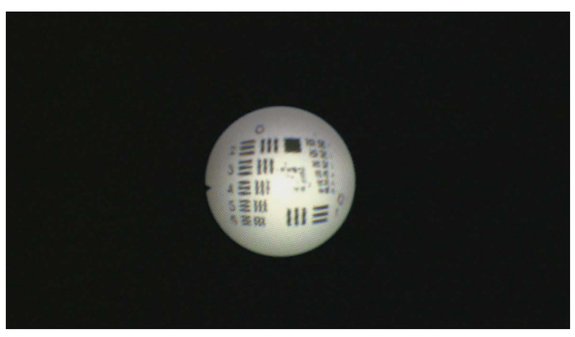

Figure 4: USAF 1951 resolution target - X^2

Results Optics and Questionnaire:

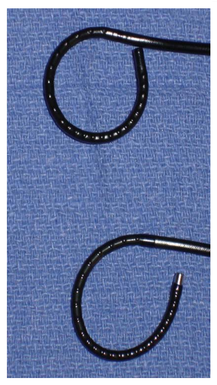

Figure 5: X^C, X^2 downward deflection

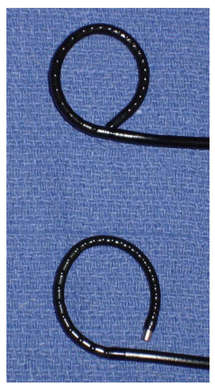

Figure 6: X^C, X^2 upward deflection

The X^C had a higher resolution than the X^2 at 20 and 10 mm - 3.17 lines/mm vs. 1.41 lines/mm, 10.1 vs 3.56, respectively (p=0.003,p=0.002). Color representation was also better in the X^C.

	Storz XC	Storz X2	p-value
Resolution (lines/mm) at			
10 mm	3,17	1,41	0,003
20 mm	10,10	3,56	0,002
Grayscale imaging	Equal	Equal	
Color reproducibility	Slightly better		
Pixel	60000,00	4000,00	

Table 1: Optical results for Storz X^C vs Storz X^2

Observers deemed the distal sensor ureteroscope superior in visualization in clear and bloody fields, as well as for illumination. (p=0.0005, p=0.002, p=0.0125)

	Mean (XC)	SD	Mean (X2)	SD	p-value
Superior Scope	Scope XC		Scope XC		
Glare	8,88	0,64	6,50	0,53	0.0005
Maneuverability	9,50	0,53	9,50	0,53	1.00
Visualisation Bloody Field	9,38	0,52	6,63	0,74	0.0005
Visualisation Non Bloody Field	9,50	0,53	7,75	0,89	0.0021
Illumination	9,25	0,89	7,88	0,83	0.0125
Resolution	9,50	0,53	6,13	0,35	0.0004
Visibility	9,13	0,35	6,38	0,52	0.0003
Overall Performance	9,25	0,46	7,25	0,46	0.0004

Table 2: Results Questionnaire

Results Deflection and Flow:

When compared to the X^2, the X^C manifested superior deflection and irrigant flow (p<0.0005,p<0.05) with and without accessory present in the working channel.

		X2 Mean	SD	XC Mean	SD	t-test p-value
Empty	Up	279,83	0,29	296,83	0,29	<0.0005
	Down	273,50	0,87	292,67	0,29	<0.0005
Laser 200µm	Up	269,33	0,29	289,17	0,29	<0.0005
	Down	264,33	0,58	286,17	0,29	<0.0005
Laser 273µm	Up	245,83	0,29	256,83	0,29	<0.0005
	Down	240,33	0,29	250,17	0,29	<0.0005
Delta Wire Grasper (3.2Fr)	Up	176,33	0,29	188,83	0,29	<0.0005
	Down	170,83	0,29	186,00	0,50	<0.0005
1.7 Fr Nitinol Stone Extractor	Up	272,67	0,29	295,17	0,29	<0.0005
	Down	268,00	0,00	290,33	0,29	n/a
2.2 Fr Nitinol Stone Extractor	Up	252,33	0,29	272,50	0,50	<0.0005
	Down	245,17	0,29	268,00	0,50	<0.0005

Table 3: Angles of deflection

		X2 Mean	SD	XC Mean	SD	Interaction p-value
Empty	Flow	59,33	0,29	62,83	0,58	0,0007
Laser 200µm	Flow	28,33	0,29	32,50	0,00	n/a
Laser 273µm	Flow	26,50	0,00	28,00	0,00	n/a
Delta Wire Grasper (3.2Fr)	Flow	0,50	0,10	0,97	0,06	0,0022
1.7 Fr Nitinol Stone Extractor	Flow	16,33	0,29	18,33	0,29	0,0011
1.7 Fr Nitinol Stone Extractor	Flow	6,83	0,29	8,83	0,29	0,0011

Table 4: Results Flow

Conclusion: In this *in vitro* and porcine evaluation the distal sensor ureteroscope appears to provide significantly improved resolution and color representation as compared to a standard fiberoptic ureteroscope. The overall deflection was also better in the X^C and deflection as well as flow rate was less impaired by the various accessories. Clinical corelation is pending.