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A naked-eye comparison of image quality between a portable versus a fixed camera system for digital flexible ureterorenoscopy – A single centre experience

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ABBREVIATIONS

ENT, ear, nose and throat;
URS, ureterorenoscopy

Abstract ***Objective:*** To assess the image quality using the portable OTV-SI (Olympus, Southend, UK) light source system compared to a dedicated fixed standard stack system for flexible ureterorenoscopy (URS) as judged by the human eye.

Methods: We compared two differing flexible URS set-ups. The first was our normal completely digital fixed set-up, comprising a flexible ureteroscope and matching digital stack system (CLV-S40 PRO-6E, Olympus). The second set-up comprised the same digital ureteroscope but with a conventional non-digital stack system and the OTV-SI portable light source. Seven experienced urologists were asked to subjectively assess the quality of the video sequences with the naked eye. The image qualities assessed were as follows: colour, distortion, graininess, depth perception, contrast, and glare. Finally, they were asked to guess whether they were observing images from the normal fixed set-up or the portable set-up. Fisher's exact test was used to compare the two sets of nominal variables.

Results: There were no significant differences in the observation ratings between the fixed and portable systems, independent of observer or image settings. Also, the surgeons were not able to correctly guess which stack system had been used.

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Conclusion: For flexible URS imaging, the combination of a digital ureteroscope with a conventional non-digital stack system together with the OTV-SI portable light source was subjectively found not to be inferior to the completely digital fixed set-up. Thus, the cheaper and smaller portable system could be considered as an economical option without substantial loss of image quality, especially useful in developing countries.

Introduction

In recent decades technological advances have transformed stone surgery and resulted in the development of endourology as a subspecialty. We have in this short time relegated open stone surgery to a bookmark in history and currently we witness the ongoing rise of the flexible ureteroscope [1]. The boundaries of ureterorenoscopy (URS) are constantly expanding and being pushed further. Marshall [2] first described the use of a flexible ureteroscope in 1964, when a 9-F flexible ureteroscope was used to inspect the renal calyces. Further developments of flexible URS would wait another couple of decades however. In the early eighties, Bagley's group in Chicago further developed the flexible ureteroscope demonstrating active deflection, which greatly aided navigation of the tip to the point of interest, as opposed to the previous techniques relying on mere passive deflection [3].

Subsequently, we have seen the rapid development and application of flexible URS as a potent tool in the armamentarium of the endourologist. It has been successfully used in the treatment of intrarenal calculi with effective and safe treatment of ever larger stones conventionally managed with percutaneous nephrolithotomy. The advent of digital ureteroscopes has allowed for better visualisation, especially in the cases of transitional cell tumours of the ureter and kidney. This has facilitated successful topical management of these tumours in patients' unfit or declining radical treatment.

Despite the above, it would be far too simplistic to state that the digital flexible ureteroscope is an essential tool for the endourologist without considering its limitations. Firstly, there is the cost of the scope together with the additional costs of the specific stack system comprising camera, light source and image processing hardware [4]. Although the cost of the ureteroscope may not be disagreeable, the cost of the stack system however can be, and the prospective purchaser may be deterred by having to change their whole existing stack system when changing to digital. A possible cost-saving solution could be a portable system, i.e. the OTV-SI (Olympus, Southend, UK; Fig. 1). In the present study, we assessed the subjective image quality of this portable system compared to a dedicated fixed standard stack system for flexible URS.

Methods

The Olympus OTV-SI is a compact integrated camera control unit and light source that has been introduced for use in fibre optic endoscopy, with current users including ear, nose and throat (ENT) surgeons, anaesthetists, and gynaecologists. It is possible with this system to use a digital flexible ureteroscope together with an existing (analogue, non-digital) stack system. The OTV-SI can process and output the digital signal from the flexible ureteroscope to any conventional monitor.

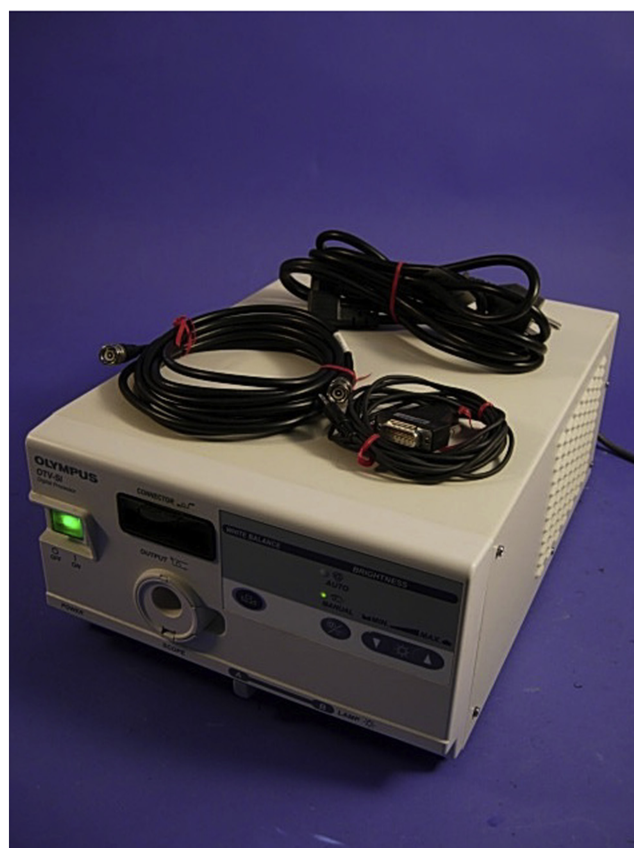

Fig. 1 The Olympus OTV-SI portable system.

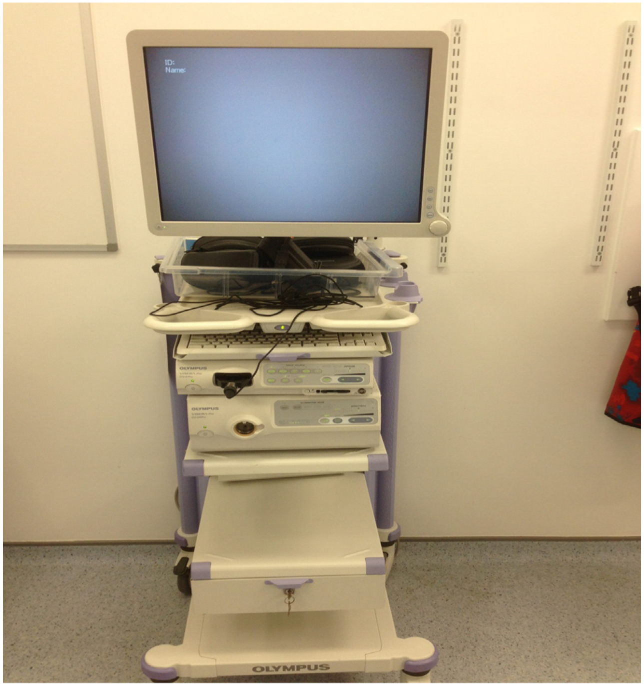

Fig. 2 The Olympus CLV-S40 PRO-6E stack system for digital flexible URS.

However, this results in a conversion of the digital source to a lower quality output in the conventional monitor. If the conventional monitor is digital then the signal will remain a digital signal, but if the monitor is analogue or of a lower resolution the image will be downscaled.

We were lucky enough to have at our disposal a complete digital flexible URS system (URF-V, Olympus) and the matching digital stack system (CLV-S40 PRO-6E, Olympus; Fig. 2). We therefore compared two differing set-ups. The first was our normal arrangement with the complete fixed digital set-up. The second arrangement was using the same digital ureteroscopes, but this time with a conventional non-digital stack system together with the portable OTV-SI.

We then conducted an assessment with seven experienced urologists assessing the quality of the pre-recorded video footages using the different stacks and settings. All assessors were senior surgeons within a dedicated endourology unit with ample experience in both, analogue and digital flexible URS. They were blinded as to which arrangement was being shown to them. Video sequences from the same patient were shown to individual surgeons in varying sequences. Each surgeon was asked to observe two different settings – one using the portable OTV-SI system with an analogue stack and the other using the fully digitalised fixed stack system. They will be referred to as 'portable' and 'fixed' systems respectively in our discussion. The surgeons were asked to assess the following image qualities: colour, distortion, graininess, depth perception, contrast, and glare. Finally, they were asked to guess which set-up they were actually observing. Grading was on a scale from 1 to 5 corresponding to very poor to very good.

The Fisher's exact test was used to compare the two sets of nominal variables. The Fisher's exact test was preferred over the chi-square test due to the relatively few observations.

Results

The results of the image assessment are summarised in Table 1 for each of the six qualities studied – colour, distortion, graininess, depth perception, contrast, and glare. The *P* values were all non-significant, thus suggesting there was no difference in the observations between the two groups. Image quality perception by the urologists was overall not different between the fixed and portable systems, independent of observer or image settings.

We also asked the urologists to guess which stack system had actually been used – the fixed or portable. When being shown the fixed system, in 57% of cases they correctly guessed the fixed system. When being shown the portable system they were correct in 50% of cases (Table 2). This highlights that they were not able to correctly guess which stack system had been used with the flexible ureteroscope on the basis of image quality.

Discussion

Endourology is a specialty that has advanced in recent decades through novel technologies. We have seen advances in both analogue and digital flexible ureteroscopic technologies [1].

Flexible URS allows for the treatment of increasingly larger stones in the kidney thus decreasing the role of percutaneous nephrolithotomy and open surgery. As an adjunct with percutaneous nephrolithotomy it has been used simultaneously to clear complex stones at one sitting and also to aid renal access. Thus, we are seeing a greater role and greater uptake of flexible URS worldwide.

Digital scopes provide a better resolution and colour reproduction [5]. This improved visualisation is advantageous in the diagnosis and treatment of tumours of the ureter and kidney, where often the changes may be subtle and slight. In addition, the improved visibility can lead to faster stone disintegration.

On the other hand, analogue scopes do retain some advantage over their newer digital counterparts. Flexible ureteroscopes as such remain much more delicate instruments than their semi-rigid counterparts and have a limited durability [6]. Digital flexible scopes have a similar life-span as analogue ones [7], but are much more expensive to replace or repair.

Table 1 Assessment of image properties and qualities.

Image quality assessed	Observer rating, *n*				Total	P^*
	Poor	Adequate	Good	Very Good		
Colour						0.588
Fixed	0	4	12	5	21	
Portable	0	5	7	2	14	
Total	0	9	19	7	35	
Distortion						0.558
Fixed	0	4	10	7	21	
Portable	0	5	6	3	14	
Total	0	9	16	10	35	
Graininess						0.348
Fixed	0	4	13	3	21	
Portable	2	3	5	3	14	
Total	2	7	18	6	35	
Depth perception						0.545
Fixed	0	5	6	10	21	
Portable	0	5	2	7	14	
Total	0	10	8	17	35	
Contrast						0.345
Fixed	0	8	9	4	21	
Portable	0	6	3	5	14	
Total	0	14	12	9	35	
Glare						0.830
Fixed	1	4	6	10	21	
Portable	2	2	3	7	14	
Total	3	6	9	17	35	

* Fisher's exact test.

Table 2 The urologists' opinion of which stack system had actually been used.

Stack system	Guessing which system was used, *n*		Total, *n*
	Correctly identified	Incorrectly identified	
Fixed	11	10	21
Portable	7	7	14

To date, most digital scopes are slightly larger in calibre due to their 'chip-on-the-tip' design, and it has been shown that they require access sheaths for their insertion more often than analogue scopes.

But most importantly, the initial capital costs for a special digital stack system of ~35,000 Euros, which has to replace any existing stack system when switching from analogue to digital flexible URS, and the higher repair and replacement costs of ~15,000 Euros for digital flexible scopes, as opposed to ~5–7000 Euros for analogue scopes after an average use in ~20 cases is what hinders many hospitals and surgeons from switching to digital technology, especially in government institutions and developing countries. For modern ureteroscopes, in the USA an average of 600 American dollars has to be added to the treatment costs for each patient for repairs alone [4].

By using a portable compact integrated camera control unit and light source, such as the Olympus OTV-SI, these capital costs can be brought down significantly without, as our present study shows, jeopardising the subjective picture quality for the surgeon. The differences perceived subjectively by the assessors if any, such as graininess, did not reach statistical significance. Whereas this may be biased by the small number of assessments, it did not change the overall picture of similarity and lack of distinction between the two systems (Table 2).

Even when combined with an existing analogue stack system, surgeons will still be able to benefit from the enhanced image resolution and colour display provided by the digital 'chip-on-the-tip' technology with digital enhancement [8].

Portable endoscopy is common place in other medical specialties, such as ENT, and has been adopted well in countries where office urologists perform flexible endoscopies in their own practice setting wanting to bring down bulkiness and price without jeopardising image quality. Consequently, manufacturers have invested in improving the image quality of such systems [9].

We do acknowledge some shortfalls of our present study. Firstly, the assessments are subjective and very hard to objectively verify. We are relying here on a subjective picture of a, albeit experienced, human eye. Secondly, the number of assessors was limited making statistical analysis difficult to interpret. Thirdly, we did not compare imaging systems from different manufacturers and can therefore only interpret our present results for the given set of equipment.

To achieve a technically sound analysis, one would have to test this with a much larger group of assessors, preferably using standardised test pictures or video sequences.

However, we nevertheless believe that this small study may show tendentiously that a cheaper and smaller portable system can be an option without substantially losing image quality. This in turn may increase the uptake of digital flexible URS to the benefit of patients in the future, especially in smaller settings and developing countries.

Conflicts of interest

None.

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