

## AIMS AND OBJECTIVES

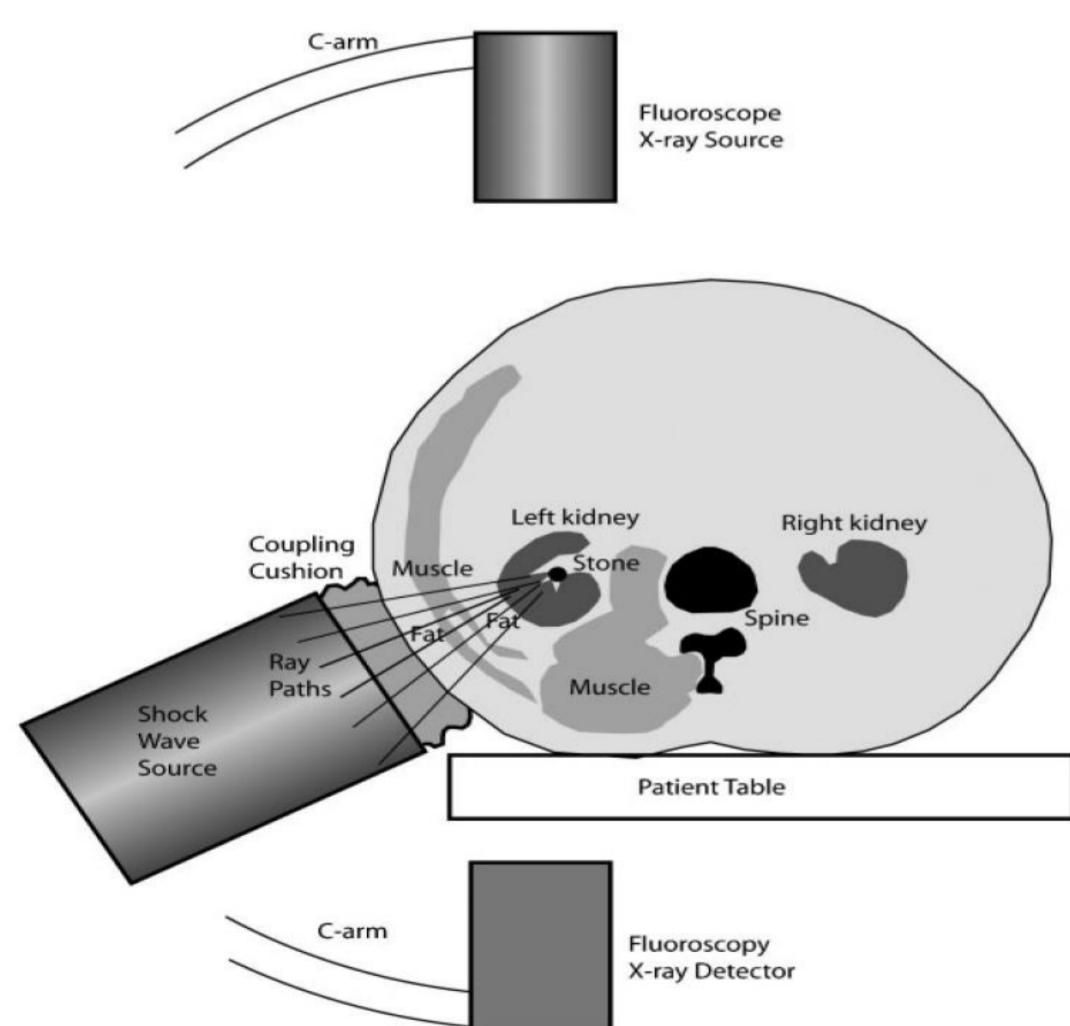
Extra-corporeal shockwave lithotripsy (ESWL) uses non-linear sound waves to break kidney and ureteric stones. The success of ESWL depends on accurate targeting of the stone within the focal zone of the lithotripter, which is complicated by stone movement due to respiration.

In vitro studies indicate that up to 75% of shockwaves may be delivered when the stone is outside of the focal zone. Stone movement >10mm significantly reduces the efficiency of fragmentation [1].

Increasing the percentage of shockwaves incident on the stone would allow the treatment dose of shock waves to be lowered, potentially reducing renal injury. At present, there is little clinical data to quantify stone movement during respiration in ESWL.

*We aimed to measure renal and ureteric stone movement secondary to respiration in patients during ESWL treatment.*

*We aimed to assess if stone movement correlated with pain.*



**Figure 1:** Schematic showing a patient lying supine on a lithotripter [2]. The stone is visualised using X-ray fluoroscopy or ultrasound. In order to minimise refraction of sound waves at the skin boundary, the shockwave source is coupled to the patient by a fluid-filled cushion, an acoustic transmission gel with sound velocity close to that of tissue, and water.

## METHODS

Fifty two patients (33 with kidney stones and 19 with ureteric stones) were treated by one of three radiographers on the Storz Modulith SLX-F2 lithotripter (Figure 2). Stones were monitored using fluoroscopy.



**Figure 2:** Storz Modulith SLX-F2 lithotripter at the Churchill Hospital, Oxford. Focal zone = 4mm diameter. (Image courtesy of R. Cleveland)

Treatment ceased when the radiographer judged the stone to be fragmented, or after 4000 shockwaves were administered.

The following data were collected at baseline, 500, 1500 and 3000 shocks:

- 2 images of kidney stones were taken by X-ray fluoroscopy, one at maximum inspiration and one at maximum expiration
- A verbal pain score (0-10)
- Respiratory rate, observed over 30 seconds

Also recorded were:

- Maximum shockwave energy and frequency
- Treatment outcome as assessed by the radiographer (fragmentation, possible fragmentation, no visible effect)

Images were analysed using ImageJ (NIH). Paired inspiratory and expiratory images were overlaid and the distance between the stone centroids was measured to give the distance moved by the stone in respiration.

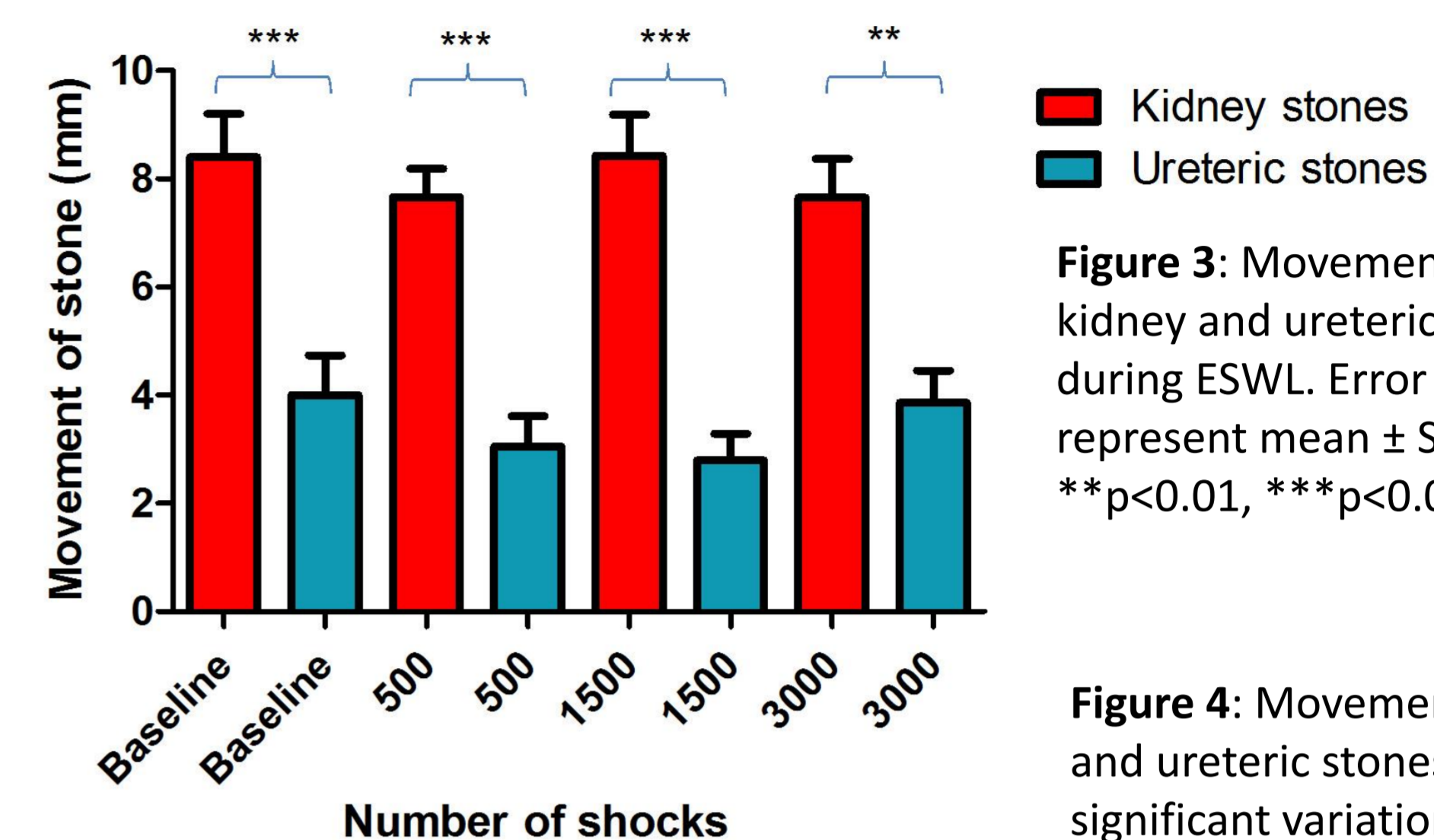
Stone movement was statistically analysed by two-way ANOVA and Bonferonni's multiple comparison test using GraphPad Prism software. Statistical significance was defined as  $P < 0.05$ .

## RESULTS

**Figure 3** shows the effect of respiration on stone movement

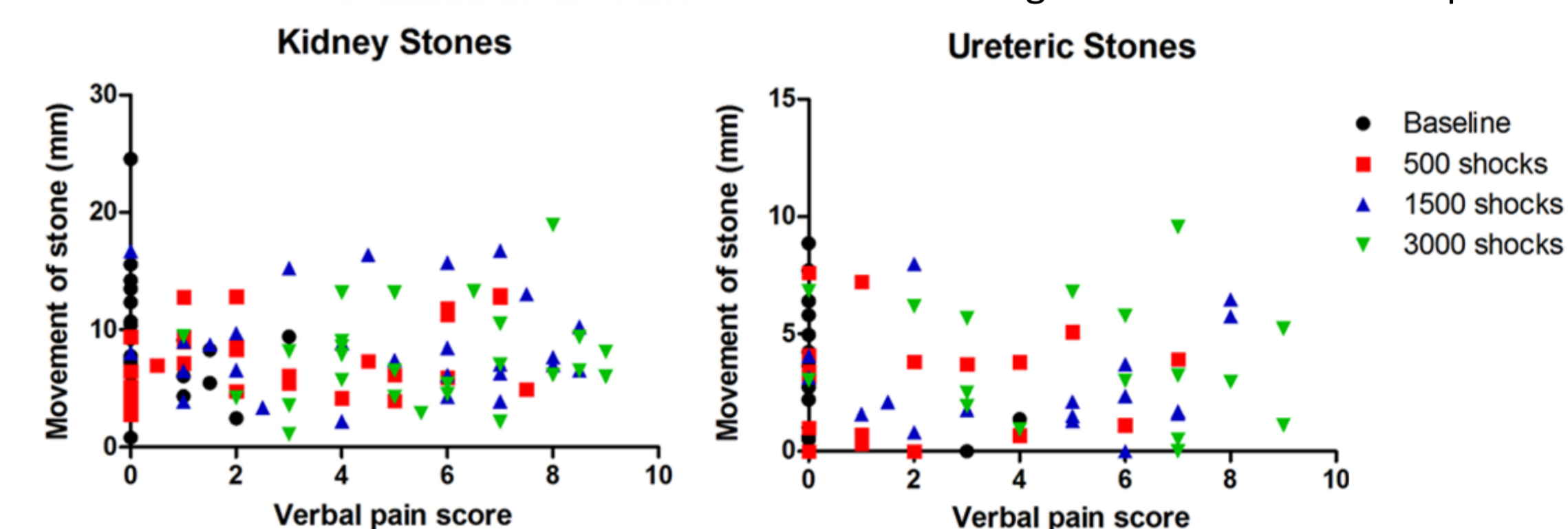
- **There was significantly less movement of ureteric stones compared to kidney stones at baseline, 500, 1500 and 3000 shockwaves.**
- **There were no significant changes in stone motion during treatment (at 500, 1500 or 3000 shocks) compared to baseline for either kidney or ureteric stones.**
- **Verbal pain score significantly increased from baseline to 500, 1500 and 3000 shocks, from 500 to 1500 shocks and from 1500 to 3000 shocks for both renal and ureteric stones**

## Stone Movement with Respiration



**Figure 3:** Movement of kidney and ureteric stones during ESWL. Error bars represent mean  $\pm$  SEM. \*\* $p < 0.01$ , \*\*\* $p < 0.001$

**Figure 4:** Movement of kidney and ureteric stones showed no significant variation with pain.



- **There was no correlation between pain and stone movement or respiratory rate (Figure 4).**

## CONCLUSIONS

1. **Movement of renal and ureteric stones due to respiration does not significantly change over the course of one ESWL treatment.**
2. **Ureteric stone movement is significantly less than kidney stone movement throughout ESWL treatment.**

The results of this clinical study suggest that movement of renal and ureteric stones due to respiration is less than the 15mm previously reported [3]. Stone movement may therefore have less impact on fragmentation efficiency than expected. Further work should examine whether there is a correlation between pain, stone movement and treatment outcome, and investigate the effect of successive ESWL treatments on stone movement and outcome.

## REFERENCES

- [1] CLEVELAND, R.O., ANGLADE, R. and BABAYAN, R.K., 2004. Effect of stone motion on in vitro comminution efficiency of storz modulith SLX. *Journal of Endourology*, **18**(7), pp. 629-633.
- [2] LEIGHTON, T.G. and CLEVELAND, R.O., 2010. Lithotripsy. *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine*, **224**(2), pp. 317-342.
- [3] SORENSEN, M.D., BAILEY, M.R., SHAH, A.R., HSI, R.S., PAUN, M. and HARPER, J.D., 2012. Quantitative assessment of shockwave lithotripsy accuracy and the effect of respiratory motion. *Journal of Endourology*, **26**(8), pp. 1070-1074.