Genitourinary tract – The pandora's box of the stones

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Abstract
Stone formation is a common disease. The prevalence of stones is consistently increasing over the past 50 years with prevalence rates of upto 14.8%. For the treatment of stones in the genitourinary tract many medical and surgical strategies exist. Minimal invasive surgeries are enough to deal with around 99% of the cases. Open surgery is needed only in 1–5.4% of cases which means that open stone surgery still has its role.

There are no studies till now where various shapes of the stones are described. Few shapes related to the stones are well described like the shape of a staghorn stone, shape of a jackstone of urinary bladder as well as the kidney. We here open up the pandora's box of the genitourinary tract and describe shapes of various funny and interesting shapes of stones as seen on x-ray KUB, IVP, CT and endoscopic images seen during surgical treatment and after open surgeries. We will also elaborate whether where open surgery or the endourological surgery is needed. This is first of its kind of a paper for this purpose only.

Keywords: Stone shapes, GU tract stones, Staghorn stone, Urinary stone shapes, Urinary stone pandora's box.

Introduction
Stone formation is a common disease. The prevalence of stones is consistently increasing over the past 50 years with prevalence rates of upto 14.8%. The 5-year recurrence rate has been estimated up to 50%.[1] Changing lifestyle, dietary habits and global warming,[2-4] further add to this. Various risk factors for stone formation are obesity,[5] diabetes,[6-8] hypertension[3,7,9] and other metabolic syndromes.[10] Stone formers patients are at risk of hypertension,[9,11] chronic kidney disease (CKD) and end-stage kidney disease (ESKD).[12-15] The costs related with the treatment of stone disease is also rising. United states has shown an increasing estimate of US$2 billion in 2000 to over US$10 billion in 2006.[16]

For the treatment of stones in the genitourinary tract many medical and surgical strategies exist. Many important advances have been made in the understanding of stone pathogenesis. Medical therapies are used to ease stone passage especially smaller stones in the kidney and the ureter, promote expulsion through the lower ureter and reduce stone recurrence. Non-invasive option for stone fragmentation includes extracorporeal shockwave lithotripsy (ESWL) to enable the stone fragment internally by external shock waves. Fragments of stone later on pass in the urine. ESWL was introduced by Chaussy et al in 1982 into routine clinical practice.[17]

The surgical treatment of urolithiasis has changed significantly over the past 30 years. Surgical options to remove stones from various sites in the genitourinary tract includes minimal invasive options and open surgeries. Minimal invasive options include laproscopic and endoscopic surgeries. Endoscopic surgeries include percutaneous nephrolithotomy (PCNL) of different varieties like standard PCNL, mini-PCNL, mini-perc, microperc, ultramini perc and so on. PCNL involves direct endoscopic access into the kidney through a small incision in the flank. This is followed by retrograde intrarenal surgery (RIRS), where surgery is performed using a flexible fibre-optic ureteroscope to access the upper urinary tract through natural passageways. Then comes the semi-rigid ureteroscope for the ureteric stone. This is followed by cystolithotripsy for the bladder stones. All these minimal invasive surgeries are enough to deal with around 99% of the cases.

Advances in the endoscopic management of stone disease has nearly reduced the indications of open surgeries. Open surgery for has now become a second- or third-line treatment option. All those centres who are well equipped, has expertise and experience in the surgical treatment of renal tract stones report that open surgery is needed only in 1–5.4% of cases [18-21]. This means that open stone surgery has still its role.

There are no studies till now where various shapes of the stones are described. Few shapes related to the stones are well described like the shape of a staghorn stone, shape of a jackstone of urinary bladder as well as the kidney. We here describe shaped of various funny and interesting shapes of stones as seen on x-ray KUB, IVP, CT and endoscopic images seen during surgical treatment and after open surgeries. We will also elaborate whether where open surgery or the endourological surgery is needed. This is first of its kind of a paper for this purpose only.

Materials and Methods
We collected all the photographs from the photoshop collection of the computer section of the Urology section and from the radiology images collection of the Department of Surgery, SMBT IMS & RC, Nashik, Maharashtra, India and Department of Urology, Tambe Hospital, Sangamner, Ahmednagar, Maharashtra, India from August 2016 to July 2020. These photographs were collected at various times. The x-ray film photographs (plain x-ray KUB, IVP, CT film) were collected pre-operatively, intra-operative photographs were taken by the surgeon or the assistants/technicians/ward boys during the surgery and few snaps of stones were taken post-operatively after the stone was removed outside the organ of

open surgery. Patient's identity related photographs were not taken and disclosed.

Following is the variety of the different shapes and images of the stones:
Gross stone shape after open surgery –

1. Renal –
   i. Staghorn stone of kidney –complete depicting as the Lord Ganesha and his mouse
   ii. Staghorn stone of kidney – partial
   iii. Jackstones of kidney
   iv. The brave heart PUJ stone
   v. The pebble stones
   vi. The renin shaped stone
   vii. The classical foetal/renal lobulations
   viii. The cauliflower kidney
   ix. The foetus in the kidney
   x. The goat stone

2. Ureteric - The rod shaped tubular ureteric calculus
3. Vesical
   i) Jackstone of urinary bladder
   ii) Large smooth round small ball like bladder diverticular stone
   iii) The phallus inside the bladder
   iv) The Eclairs stone
   v) The coral shaped stone
   vi) The egg stone
   vii) The diamond ring bladder stone
   viii) The idli bladder stone in a neurogenic bladder
   ix) The pebbles in the bladder
   x) The robotic stone

Discussion

Various treatment options for the removal of stones in the kidney, ureter and bladder are ESWL, PCNL, URSL and cystolithotripsy. The improvement in the endourological management of stones in last three decades have revolutionised the stone treatment and changed the indications of open surgery. The role of open surgery is decreasing day by day, still in few selected cases, it firmly has a role like in the situations of complex and large renal staghorn stones, large bladder stones, etc or where there is complex renal anatomy or associated pathology like UPJ obstruction, diverticulum, etc. Sometimes patient's characteristics and failure of primary therapy for stone removal becomes the indication for open surgery.

There are few large or differently shaped stones that need recognition for their different look. Few among these are the well-known staghorn stones of the kidney and the jackstones of kidney and the bladder and the mulberry stones.[22] The other being large smooth ball shaped stones of the bladder.

Staghorn stones derive their name form the stag of the reindeer that has multiple branching pattern. Jackstone derive their name from the resemblance to a child's toy jacks.

We will now describe here various shapes of the stones that we got in our clinical day to day practice.

Staghorn stone of kidney –complete depicting as the Lord Ganesha and his mouse

Complete staghorn stone means that the large branching stones that fill part of all of the renal pelvis and renal calyces. These stones were removed by open surgery owing to their size and the complexity.

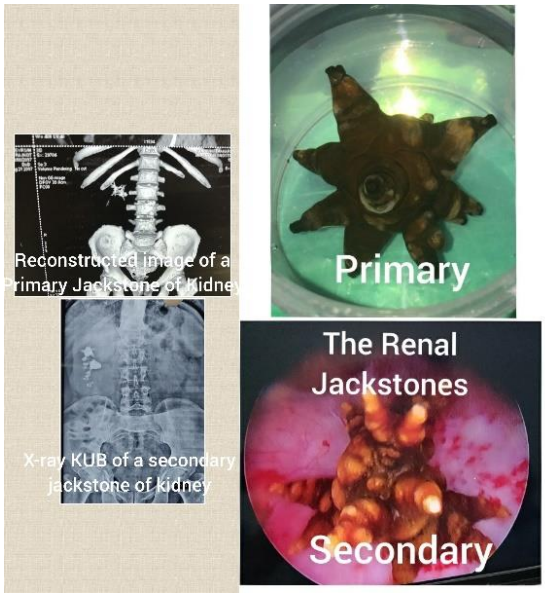
Here we can well appreciate different parts of the body as marked.

Staghorn stone of kidney – partial

It means the stone partially fills the pelvis and one or two calyces. Note the large base occupying the pelvis and the two horns. These were also removed by open surgery.

Jackstones of kidney

These are uniquely spiculated shape and similar appearance to toy jacks. Very rare in the upper renal tract.[23] Note the spikes in the reconstructed CT image. The primary stone was removed by open surgery and patient's consent was taken here explaining the rarity of the stone and the typical shape of the stone. The other was the image of a secondary jackstone and removed after fragmentation during PCNL.



The brave heart PUJ stone

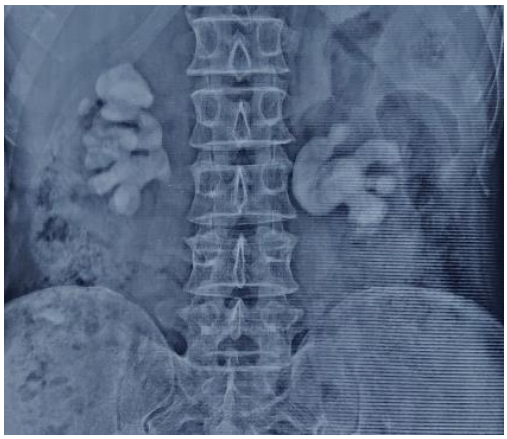
This takes the shape of a heart. This stone was an obstructed PUJ stone that maintained its shape as it was stuck there completely. This continued to beat until it was removed by PCNL. It was rescued by the urology team.

The pebbles in the kidney

These were the secondary stones formed in a non-functioning kidney due to PUJ obstruction. Look like historians' pebbles - rare stones.

The renin shaped stone

Here the staghorn stone takes the shape of the kidney it occupies. We here present simultaneous bilateral renin shaped staghorn calculi. These stones were also removed by open surgery noticing the huge size and the complex nature. The best thing was that the patient had only mild symptoms and did very well after surgery. The kidneys were full of frank pus intra-operatively.



The classical foetal/renal lobulation

In this case complete kidney became a stone. Though putty kidney is known in genitourinary tuberculosis (GUTB),[24] this was not the case of genitourinary tuberculosis. We ruled out GUTB here. Note classical renal/foetal lobulation, typical of a stone that moulds and takes the shape of the kidney.

This patient had bilateral such stones and the kidneys were just a thin rim of parenchyma, still nephrectomy was not done and only stones were removed. He survived without haemodialysis for about one year and then he was on regular haemodialysis.

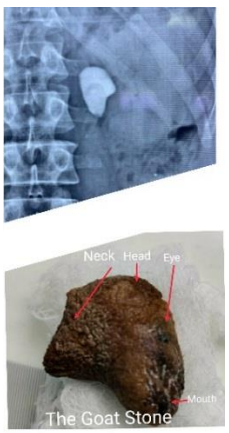
The cauliflower kidney: Here the stone is like a staghorn but nearly all individual calyces are filled with the multiple small stones. We cannot clear such stones with an open surgical approach. Here comes the role of multi-puncture PCNL for complete clearance. It took around three and a half hours for us to completely clear the kidney on one side.

The foetus in the kidney

This was a huge renal stone formed in a malrotated kidney. It was removed endoscopically by PCNL. It took four hours to break and remove all the fragments. Note the typical shape a foetus takes inside the womb with formation of head, body and the folded limbs.

The goat stone

This was a large staghorn calculus of the left kidney. It was removed by transperitoneal laproscopic pyelolithotomy. Note the parts of the head of the goat as marked.



Ureteric - The rod shaped tubular ureteric calculus

This was a long ureteric stone that we removed by open surgery, done very rarely now a days. The patient is same as above who presented with bilateral renin shaped staghorn stones. So, we did simultaneously three surgeries in this patient. The approach was midline transperitoneal. Note the size of the stone, it was more than 12cm.

Jackstone of urinary bladder

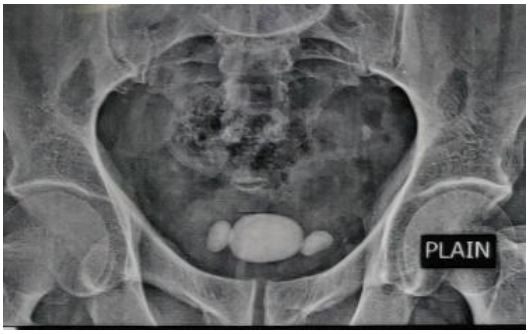
We had our study of jackstone published in 2017 over the jackstones. In that study we showed different variety of jackstones, partial and complete, their methods of removal, complications and further treatment needed. Note the classic and the coral/mulberry stone.[25]

Different varieties of Jackstone

1. **Large smooth round small ball like bladder diverticular stone:** This type of stone formed in a bladder outlet obstruction patient with a large diverticulum. Note the round shape of the diverticulum taken by the stone.

2. **The phallus inside the bladder:** This was really funny. We got two types here. In one patient the x-ray KUB typically showed the shape of phallus. Multiple bladder stones were arranged in that typical fashion. In another patient, the bladder stone during the cystoscopy looked like a phallus. All the stones were fragmented endoscopically and taken out.


3. **The Eclairs stone:** This was again multiple bladder calculi arranged in the shape of an eclair's toffee. This was again removed endoscopically after fragmentation.



4. **The coral shaped stone:** This is also a bladder stone. This was discussed among the jackstone of bladder. It was removed by open surgery.

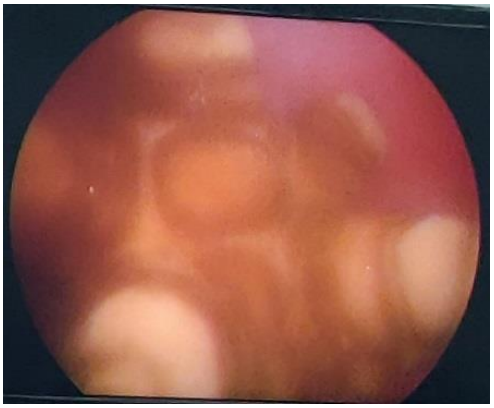
5. **The egg stone:** This was a bladder stone formed in a child of DESD where bladder neck reconstruction was done. The stones were formed over the sutures. A lot bulk was removed by open surgery. We had to use lithotripsy during open surgery to break the stone before removal alongwith an intact large glistening egg shaped stone.

6. **The diamond ring bladder stone:** We discovered it during cystoscopy. There was calculus formation over the lower end of the double J stent. This was a forgotten double J stent. Cystolithotripsy was done and the stones alongwith the stent was removed.

7. **The idli or bun shaped bladder stone in a neurogenic bladder:** These were the bladder stones formed in a patient of neurogenic bladder. Note the typical shape and curves of the idli. Idli is a south-Indian food. Th stones were typically white coloured when removed looking like idli and later on became yellowish on exposure to air.

8. **The pebbles in the bladder:** These were multiple bladder stones formed secondary to a huge prostate. Open prostatectomy was done and the stones were also removed.

9. **The robotic stone:** This stone was discovered during cystoscopy done for multiple bladder calculi secondary to benign enlargement of prostate. Note the typical robotic shape. These calculi were removed by cystolithotripsy.



Conclusion

Most of us routinely do stone surgery daily. But only very few shapes of the stones are reported like staghorn and jackstone calculi. Daily practice stone also need to be reported to increase the awareness regarding the stones among various disciplines and patients.

Abbreviations

PCNL – Percutaneous nephrolithotomy, DJ Stent – double J stent, URSL – ureterorenoscopic lithotripsy, ESWL – extracorporeal shock wave lithotripsy, OR – operating room.

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Conflicts of Interest

All contributing authors declare no conflicts of interest.

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