DOI: https://doi.org/10.4038/slju.v17i1.4132

Sri Lanka Journal of Urology, 2026, **17**(1), 12-24

Original Article

Comparative Analysis of Urinary Stone Composition and Anatomical Distribution in Sri Lankan and United Kingdom Cohorts: A Retrospective Observational Study

Samarasinghe R. N.[1], de Silva W. A. S.[2], Raheem R.[3], Chaudry A.[3], Samarakoon P.[4], Madanayake S.[5]

[1]Senior Clinical Fellow in Urology, Bedfordshire Hopsitals NHS Trust, United Kingdom.

[2]Consultant Urologist, National Hospital, Colombo, Sri Lanka.

[3]Consultant Urologist, Bedforshire Hospitals NHS Trust, United Kingdom.

[4]Senior Registrar in Chemical Pathology, National Hospital, Colombo, Sri Lanka.

[5]Acting Consultant Chemical Pathologist, Colombo North Teaching Hospital, Sri Lanka.

Abstract

Introduction: Urinary stone disease is a common urological condition with considerable geographical variation in stone composition, reflecting differences in metabolic, environmental, dietary, and socioeconomic factors. Characterising stone composition is essential for understanding disease pathogenesis and developing effective preventive strategies.

There were no previous direct comparison study between UK and Sri Lankan stone composition using FTIR method.

Objectives: To determine the chemical composition of urinary calculi in a Sri Lankan cohort, compare the findings with those of a United Kingdom (UK) cohort, and evaluate variations in stone composition according to anatomical site of origin.

Methods: A retrospective comparative observational study was conducted using Fourier-transform infrared (FTIR) spectroscopic analysis of urinary calculi. 61 stones from Sri Lankan patients and 62 stones from UK patients were analysed. Stone composition, demographic characteristics, and anatomical site of origin were compared between the two cohorts. Statistical analyses included the independent-samples t-test, chi-square test, and Fisher-Freeman-Halton exact test, with $p < 0.05$ considered statistically significant.

Results: The UK cohort was significantly older than the Sri Lankan cohort (mean age 57.6 ± 16.8 vs 50.2 ± 13.6 years; p=0.008). Calcium-based stones predominated in the UK cohort (93.5% vs 59.0%; p<0.0001), whereas uric acid stones were significantly more common in the Sri Lankan cohort (31.1% vs 3.2%; p<0.0001) than UK cohort. Struvite stones were observed frequently in Sri Lankan patients (5.2% vs 3.2%). In the Sri Lankan cohort, stone composition varied significantly according to anatomical site, with calcium oxalate stones predominating in the upper urinary tract and uric acid stones in the lower urinary tract (p=0.039). No significant association between stone composition and anatomical site was identified in the UK cohort.

Conclusion: This first direct comparative study of urinary stone composition between the UK and Sri Lanka, using FTIR, demonstrates significant differences between the cohorts. Stones in the Sri Lankan cohort were more heterogeneous, with a mixed metabolic-infective profile, whereas calcium-based stones predominated in the UK cohort. The marked variation in stone composition by anatomical site among Sri Lankan patients emphasises the need for tailored preventive strategies, including optimisation of hydration, metabolic assessment, infection control and timely management of indwelling urinary devices.

Keywords: Stone composition, spectroscopic analysis, calcium-based stones, uric acid stones, metabolic profile, indwelling devices

Introduction

Urinary stone disease is one of the oldest recognised human diseases and remains a major global health problem, affecting approximately 5-13% of the world's population (1-3). It is among the most common urological conditions requiring acute hospital admission and may result in serious complications, including urinary tract obstruction, urosepsis, acute kidney injury, renal parenchymal damage, and chronic kidney disease if left untreated.

Accurate determination of urinary stone composition is fundamental to the management and prevention of recurrent stone disease. Stone analysis provides valuable information regarding the underlying pathophysiological mechanisms and guides metabolic evaluation, risk stratification, and the selection of appropriate preventive strategies (4). Since the first identification of uric acid and cystine stones in the eighteenth century, several analytical techniques have been developed for stone analysis (5). Among these, Fourier-transform infrared (FTIR) spectroscopy has become the preferred method owing to its high analytical accuracy, sensitivity, specificity, rapid processing time, and relatively low operating costs (6,7).

The composition of urinary calculi varies considerably between populations and is influenced by geographical, environmental, dietary, metabolic, and socioeconomic factors. Countries within the Asian Stone Belt, including Sri Lanka, have been reported to demonstrate distinct patterns of stone composition, potentially related to climatic conditions, dehydration, dietary practices, recurrent urinary tract infections, and healthcare access (8). In contrast, populations in developed countries generally exhibit a predominance of calcium-based stones, reflecting differences in lifestyle, diet, environmental factors, and healthcare systems (9,10). In addition, anatomical site and the presence of indwelling urinary devices, such as ureteric stents and long-term urinary catheters, may influence stone composition through alterations in urinary stasis and susceptibility to infection.

This study aimed to determine the chemical composition of urinary calculi in a Sri Lankan cohort using Fourier-transform infrared spectroscopy, compare these findings with those of a United Kingdom cohort, and evaluate the influence of anatomical site and indwelling urinary devices on stone composition. As there was no such comparative study in the literature using FTIR method.

Methodology

This retrospective comparative observational study included patients from Sri Lanka and the United Kingdom who underwent elective urological procedures for urinary stone disease.

The Sri Lankan cohort comprised consecutive patients treated at the National Hospital of Sri Lanka, Colombo, over a six-month period from January to June 2024. Retrieved urinary calculi were analysed at the Department of Chemical Pathology, Colombo North Teaching Hospital, using Fourier-transform infrared (FTIR) spectroscopy. Demographic and clinical data, including age, sex, stone location, and surgical procedure, were obtained from patient records.

The UK cohort comprised consecutive patients managed at Bedford Hospital NHS Trust over a six-month period from January to June 2026. Stone analysis was performed at the Department of Chemical Pathology, University College London Hospitals NHS Trust using FTIR spectroscopy. Demographic and clinical information was obtained from the hospital electronic medical records. The study was conducted in parallel with the departmental stone analysis audit and received institutional approval.

The primary outcome was the chemical composition of urinary calculi. Secondary analyses compared stone composition between the Sri Lankan and UK cohorts and evaluated the association between stone composition, demographic characteristics, anatomical site of origin, and the presence of indwelling urinary devices.

Samples considered inadequate for analysis or reports affected by analytical errors due to poor specimen quality were excluded.

Statistical analysis was performed using IBM SPSS Statistics. Continuous variables were compared using the independent-samples t-test, whilst categorical variables were analysed using the chi-square test or the Fisher-Freeman-Halton exact test where appropriate. A two-sided p value of <0.05 was considered statistically significant.

Results

1. Sri Lankan cohort

A total of 61 urinary stone samples were analysed. The mean patient age was 50.2 ± 13.6 years, with a median age of 51 years (interquartile range 43.0-59.5 years) and a range of 11-75 years. There was a marked male predominance, comprising 45 males (73.8%) and 16 females (26.2%), giving a male-to-female ratio of 2.8:1 (Table 1).

Table 1. Demographic characteristics of patients in the Sri Lankan stone composition cohort (N=61)

Variable	All Patients (n = 61)
Number of stone samples	61
Age, mean ± SD (years)	50.2 ± 13.6
Age, median (IQR) (years)	51 (43-59.5)
Age range (years)	11-75
Male, n (%)	45 (73.8%)
Female, n (%)	16 (26.2%)
Male-to-female ratio	2.8:1

SD: standard deviation; IQR: interquartile range.

The highest proportion of patients was observed in the 50-59-year age group (34.4%), followed by those aged ≥60 years (26.2%). Among male patients, the peak incidence occurred in the 50-59-year age group (35.6%), whereas among female patients the highest proportion was observed in those aged ≥60 years (37.5%). Overall, 60.6% of patients were aged 50 years or older (Table 2).

Table 2. Distribution of renal stone patients according to age group and gender in the Sri Lankan stone composition cohort (n=61)

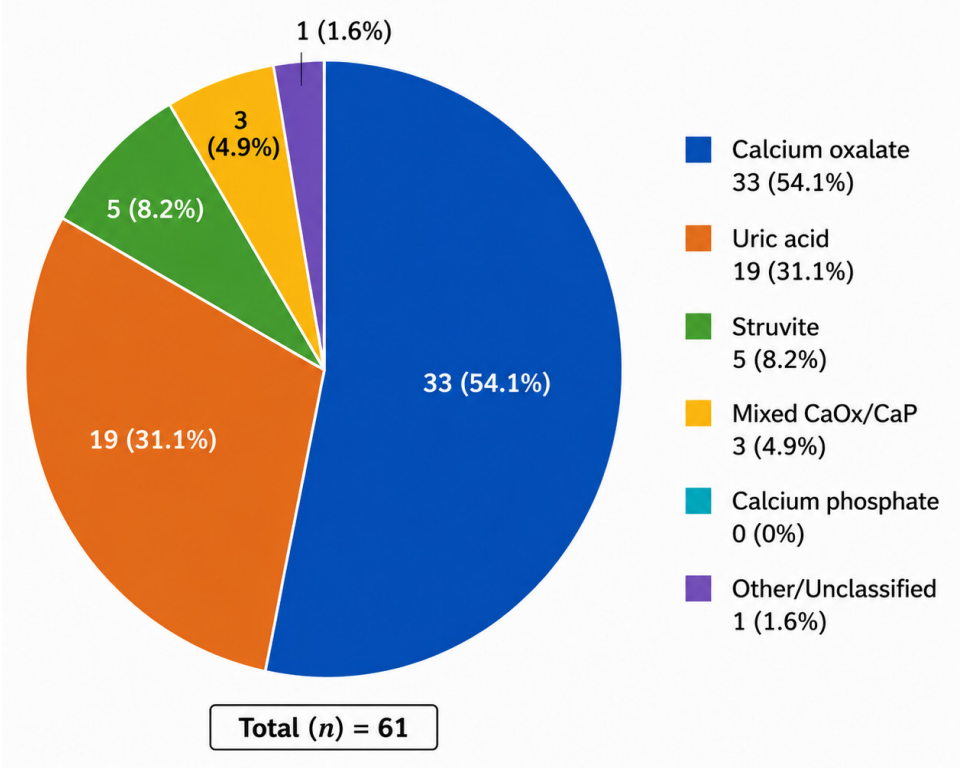
Age Group (years)	Male, n (%)	Female, n (%)	Total, n (%)
<20	1 (2.2)	1 (6.3)	2 (3.3)
20-29	0 (0.0)	3 (18.8)	3 (4.9)
30-39	5 (11.1)	0 (0.0)	5 (8.2)
40-49	13 (28.9)	1 (6.3)	14 (23.0)
50-59	16 (35.6)	5 (31.3)	21 (34.4)
≥60	10 (22.2)	6 (37.5)	16 (26.2)
Total	**45 (73.8)**	**16 (26.2)**	**61 (100.0)**

Values are presented as number (percentage within gender group for males and females, and percentage of the total cohort for the total column).

Sri Lankan stone composition analysis

Calcium oxalate was the predominant stone type, accounting for 33 of 61 stones (54.1%), followed by uric acid stones (19/61, 31.1%), struvite stones (5/61, 8.2%), and mixed calcium oxalate/calcium phosphate (CaOx/CaP) stones (3/61, 4.9%). One stone (1.6%) was classified as other or unclassified. No pure calcium phosphate stones were identified (Figure 1).

Overall, calcium-containing stones (calcium oxalate and mixed CaOx/CaP) accounted for 59.0% (36/61) of all calculi, whilst uric acid and struvite stones represented 31.1% and 8.2%, respectively.



Values are presented as number (percentage of total cohort).

Figure 1. *Distribution of stone composition in the Sri Lankan stone composition cohort (n=61)*

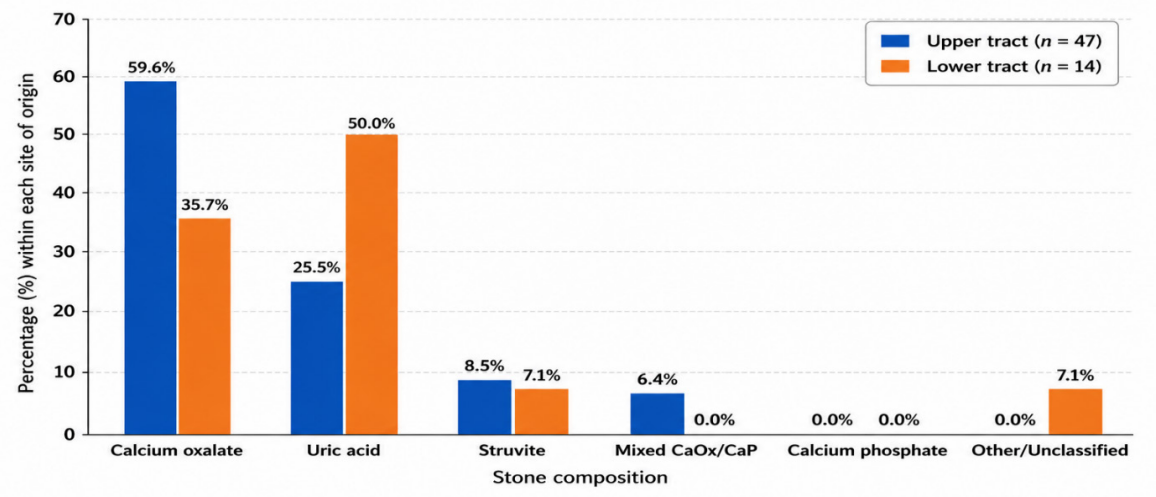
Stone composition according to site of origin

Of the 61 analysed calculi, 47 (77.0%) originated from the upper urinary tract and 14 (23.0%) from the lower urinary tract.

In the upper urinary tract, calcium oxalate was the predominant stone type (59.6%, 28/47), followed by uric acid (25.5%, 12/47), struvite (8.5%, 4/47), and mixed CaOx/CaP stones (6.4%, 3/47).

In the lower urinary tract, uric acid stones were the most frequent (50.0%, 7/14), followed by calcium oxalate (35.7%, 5/14), struvite (7.1%, 1/14), and one unclassified stone (7.1%). No mixed CaOx/CaP or pure calcium phosphate stones were identified in lower urinary tract calculi (Figure 2).

Comparison of upper and lower urinary tract calculi demonstrated a significant association between stone composition and anatomical site (χ^2=8.36, df=3, p=0.039).



values are presented as percentages within each site of origin.
CaOx/Cap = Calcium oxalate\calcium phosphate; Upper tract = *renal pelvis and ureter; Lower* tract = Urinary bladder and urethra.

Figure 2. *Distribution of renal stone composition according to site of origin (n=61).*

Calcified ureteric stents and urinary catheters

Compositional analysis was available for four calcified ureteric stents and urinary catheters. Struvite was the predominant constituent, accounting for 50.0% of samples, whilst uric acid and calcium oxalate each accounted for 25.0%. No pure calcium phosphate deposits were identified (Table 3).

Table 3. Stone composition of calcified DJ/JJ stents and urinary catheters (n=4)

Stone composition category	Number (n)	Percentage (%)
Struvite	2	50.0
Uric acid	1	25.0
Calcium oxalate	1	25.0
Calcium phosphate	0	0.0
Total	**4**	**100.0**

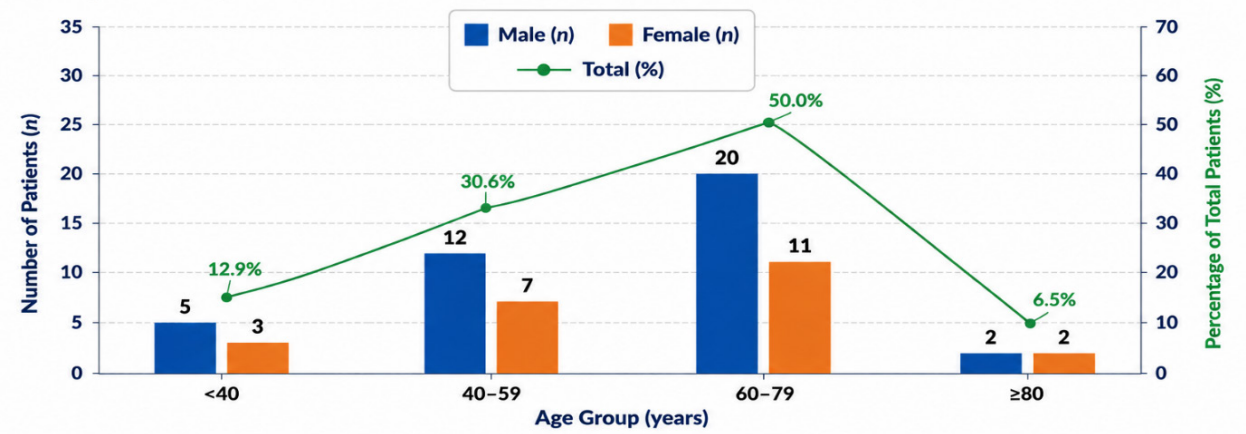
2. United Kingdom cohort

A total of 62 patients underwent stone analysis during the study period. The mean age was 57.6 ± 16.8 years, with a median age of 61 years (range 18-87 years). Males constituted 59.7% (n=37) of the cohort, while females accounted for 40.3% (n=25), giving a male-to-female ratio of approximately 1.5:1 (Table 4).

The highest frequency of stone disease was observed in patients aged 60-79 years (50.0%, 31/62), followed by those aged 40-59 years (30.6%, 19/62). Patients aged <40 years accounted for 12.9% (8/62), whilst those aged ≥80 years represented 6.5% (4/62) (Figure 3) (8/62), whilst those aged ≥80 years represented 6.5% (4/62) (Figure 3).

Table 4. Demographic characteristics of the United Kingdom stone cohort (n=62)

Characteristic	Value
Number of patients	62
Mean age (years)	57.6 ± 16.8
Median age (years)	61
Age range (years)	18-87
Male, n (%)	37 (59.7%)
Female, n (%)	25 (40.3%)
Male-to-female ratio	1.48:1



Age Group (years)	Male (*n* = 37)		Female (*n* = 25)		Total (N = 62)	
	Number (*n*)	Percentage (%)	Number (*n*)	Percentage (%)	Number (*n*)	Percentage (%)
<40	5	13.5	3	12.0	8	12.9
40–59	12	32.4	7	28.0	19	30.6
60–79	20	54.1	11	44.0	31	50.0
≥80	2	5.4	2	8.0	4	6.5
Total	**37**	**100.0**	**25**	**100.0**	**62**	**100.0**

The green line represents the percentage distribution of total stone patients across age groups in the UK cohort. UK cohort: Patients undergoing stone surgery with available demographic data (n=62).

Figure 3. *Age grop and sex distribution of stone patients in the UK cohort (n=62).*

Stone composition

Calcium oxalate was the predominant stone type, accounting for 75.8% (47/62) of all calculi. Mixed calcium oxalate/calcium phosphate (CaOx/CaP) stones comprised 11.3% (7/62), whilst pure calcium phosphate stones accounted for 6.5% (4/62). Uric acid and struvite stones each represented 3.2% (2/62) of the cohort. Overall, calcium-containing stones (calcium oxalate, calcium phosphate and mixed CaOx/CaP) constituted 93.5% (58/62) of all analysed calculi (Figure 4).

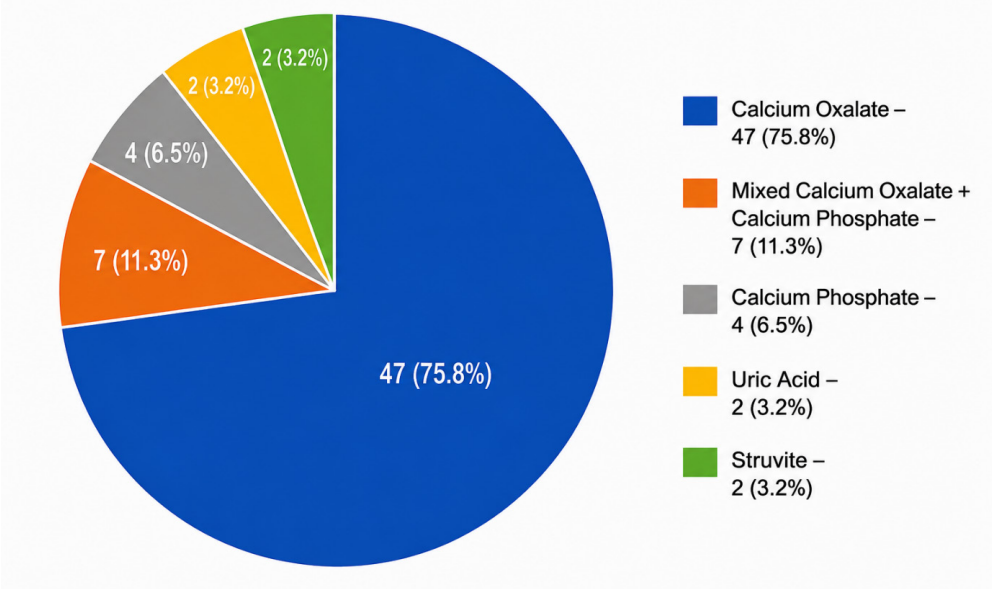


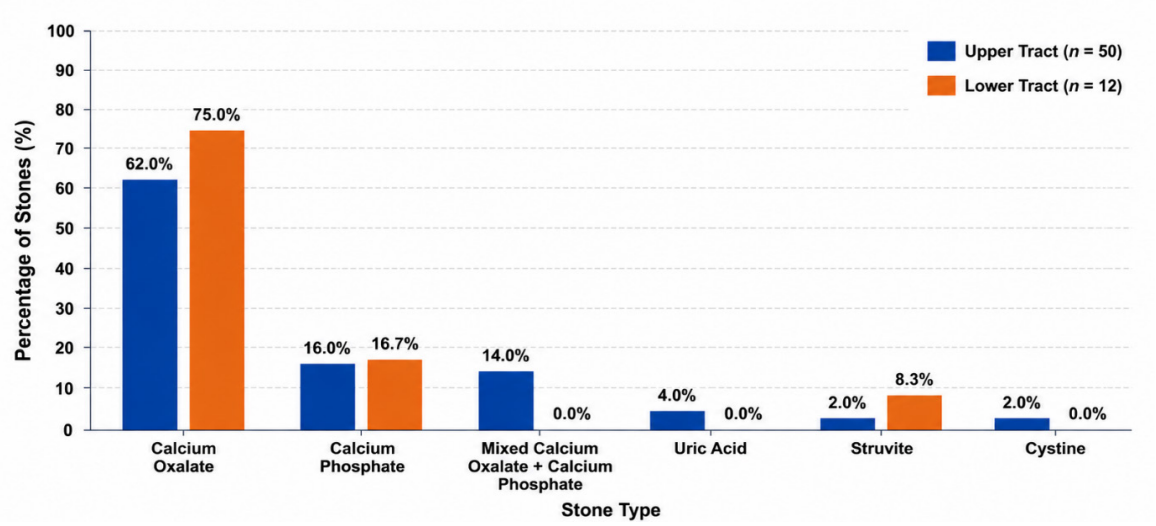
Figure 4. *Stone composition of the United Kingdom stone cohort (n=62).*

Stone composition according to anatomical site

Of the 62 analysed calculi, 50 (80.6%) originated from the upper urinary tract and 12 (19.4%) from the lower urinary tract.

In the upper urinary tract, calcium oxalate was the predominant stone type (38.0%, 19/50), followed by calcium phosphate (16.0%, 8/50), mixed CaOx/CaP (14.0%, 7/50), uric acid (4.0%, 2/50), and struvite (2.0%, 1/50).

In the lower urinary tract, calcium oxalate accounted for 75.0% (9/12) of calculi, followed by calcium phosphate (16.7%, 2/12) and struvite (8.3%, 1/12). No uric acid or mixed CaOx/CaP stones were identified in lower urinary tract calculi (Figure 5).



Stone classification was performed using the same criteria applied in the Sri Lankan cohot.

Figure 5. *Comparison of stone composition between upper and lower urinary tract calculi in the United Kingdom cohort (n=62).*

Discussion and comparison between UK and Sri Lankan cohorts

1. Age Distribution

The mean age of the Sri Lankan cohort was 50.2 ± 13.6 years (median: 51 years; range: 11-75 years), where as the mean age of the UK cohort was 57.6 ± 16.8 years (median: 61 years; range: 18-87 years).

An independent-samples t-test was undertaken to compare the mean ages between the two cohorts. The UK cohort was significantly older than the Sri Lankan cohort, with a mean age difference of 7.4 years (t ≈ -2.69, p ≈ 0.008). This finding demonstrates a statistically significant difference in age distribution between the two study populations (Figure 6).

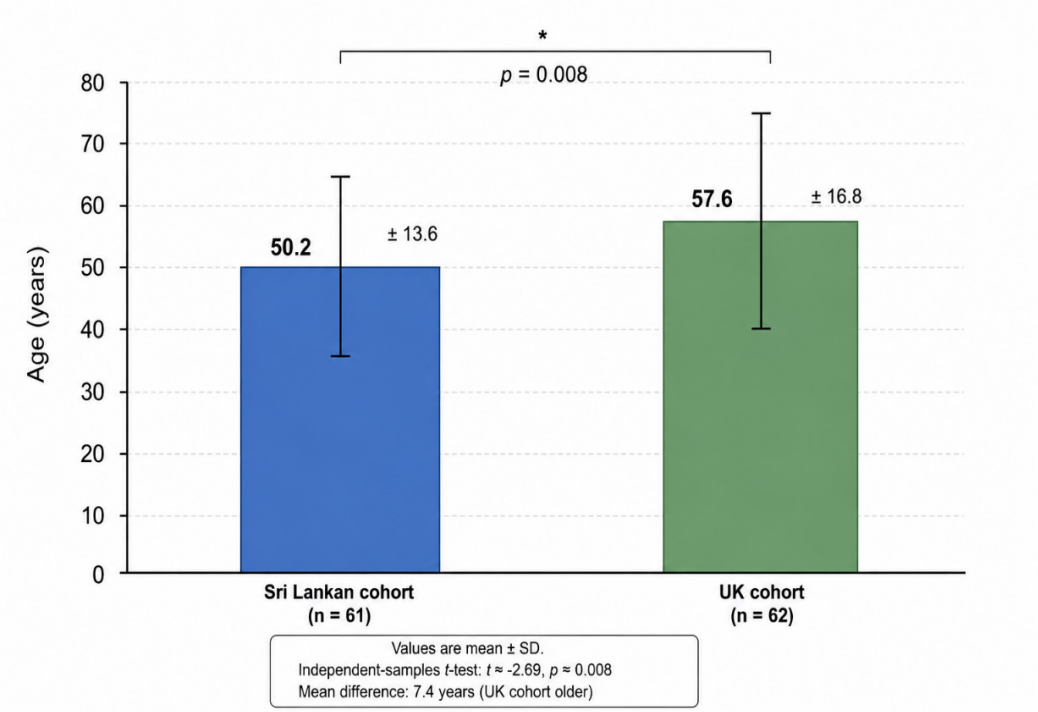


Figure 6. *Comparison of mean age between the Sri Lanka and UK cohorts.*

The older age distribution observed in the UK cohort may reflect demographic ageing, differences in healthcare utilisation, and the widespread use of diagnostic imaging, leading to increased detection of asymptomatic or incidental urinary stones (11-13).

In contrast, patients in the Sri Lankan cohort presented with stone disease approximately one decade earlier. This earlier presentation may be attributable to environmental and socioeconomic factors, including prolonged exposure to a tropical climate, chronic dehydration associated with agricultural and manual occupations, and dietary and lifestyle differences that promote earlier stone formation.

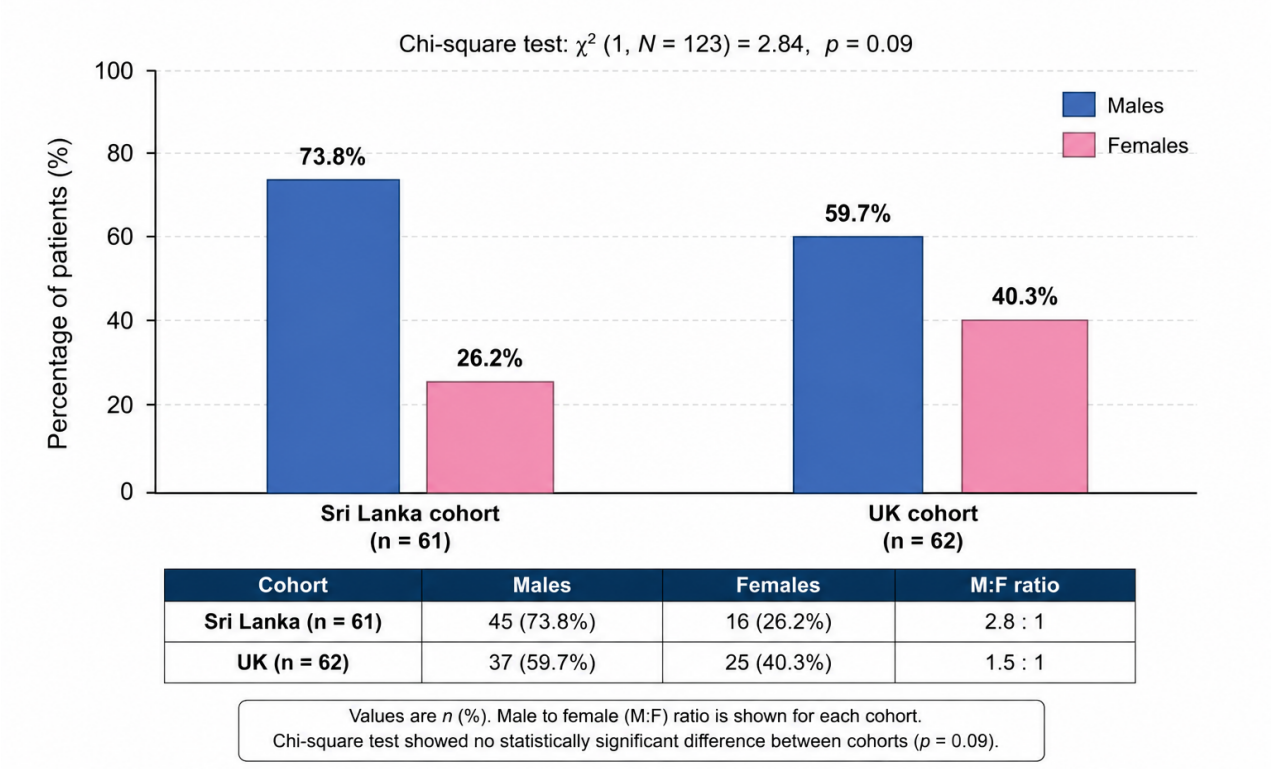
2. Sex distribution

The Sri Lankan cohort demonstrated a greater male predominance than the UK cohort, with a male-to-female ratio of 2.8:1 compared with 1.5:1, respectively.

In the Sri Lankan cohort (n=61), 45 patients (73.8%) were male and 16 patients (26.2%) were female. In contrast, the UK cohort (n=62) comprised 37 males (59.7%) and 25 females (40.3%).

Comparison of sex distribution between the two cohorts was undertaken using the chi-square test. Although the Sri Lankan cohort exhibited a higher proportion of male patients, the difference in sex distribution between the two cohorts was not statistically significant (χ^2 test, p=0.09) (Figure 7).

The male predominance observed in the Sri Lankan cohort is consistent with previous findings reported by Abeygunasekera et al., who documented a male-to-female ratio of 2.6:1 in patients with urinary stone disease (14). The greater proportion of male patients may be related to occupational exposure to high ambient temperatures, particularly amongst individuals engaged in agriculture and manual labour, resulting in chronic dehydration and an increased risk of stone formation.



Cohort	Males	Females	M:F ratio
Sri Lanka (n = 61)	45 (73.8%)	16 (26.2%)	2.8 : 1
UK (n = 62)	37 (59.7%)	25 (40.3%)	1.5 : 1

Values are *n* (%). Male to female (M:F) ratio is shown for each cohort.
Chi-square test showed no statistically significant difference between cohorts (p = 0.09).

Figure 7. *Comparison of sex distribution between Sri Lankan and UK cohorts.*

3. Age distribution and stone occurrence pattern

The Sri Lankan cohort demonstrated a predominance of stone disease in middle-aged patients. The peak age group was 50-59 years, accounting for 34.4% of cases, whilst 60.6% of patients were aged 50 years or older. These findings indicate an earlier peak in stone occurrence within a predominantly middle-aged population (Figure 8).

In contrast, the UK cohort exhibited an older age distribution. The peak incidence of stone disease occurred among patients aged 60-79 years, representing 50.0% of cases, whilst 6.5% of patients were aged 80 years or older. These findings demonstrate that stone disease in the UK cohort was predominantly observed in older adults, suggesting potential epidemiological and healthcare-system-related differences between the two populations.

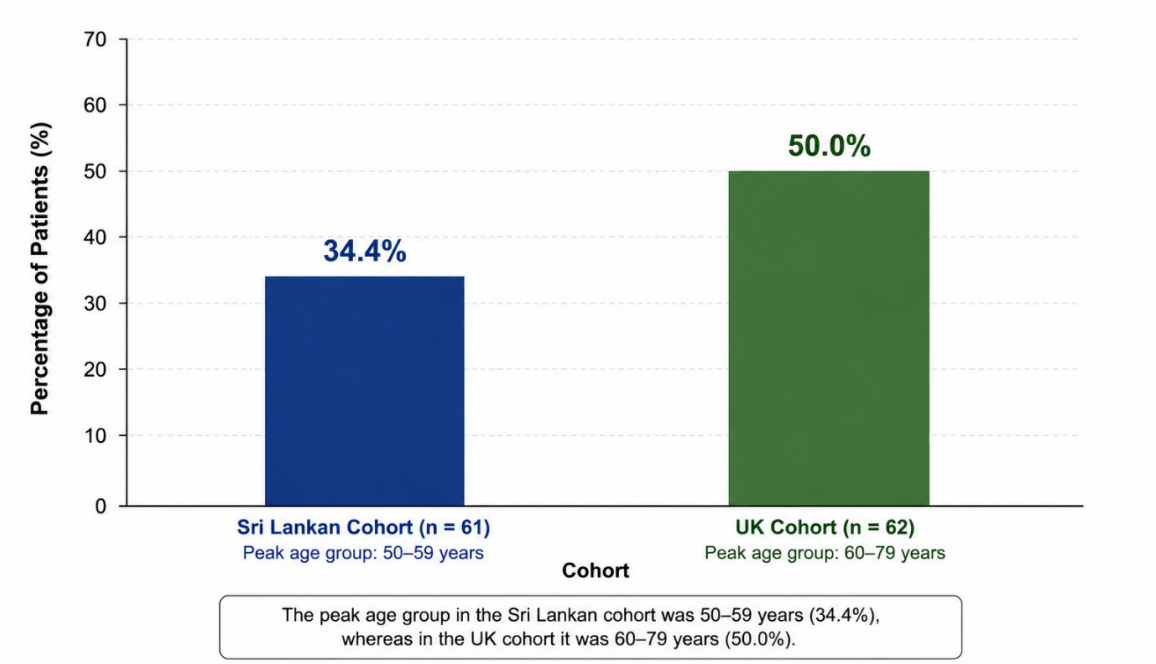


Figure 8. *Comparison of peak age groups in the Sri Lankan and UK cohorts.*

4. Stone composition comparison

The UK cohort demonstrated a marked predominance of calcium-based urinary stones, which accounted for 93.5% (58/62) of all stones, compared with 59.0% (36/61) in the Sri Lankan cohort. Calcium-based stones included calcium oxalate (CaOx), calcium phosphate (CaP), and mixed calcium-containing stones.

The difference in the prevalence of calcium-based stones between the two cohorts was highly statistically significant (chi-square test, $p<0.0001$) and was principally attributable to the substantially higher frequency of calcium oxalate and mixed calcium-based stones in the UK cohort (Figure 9).

In contrast, uric acid stones were significantly more prevalent in the Sri Lankan cohort, accounting for 31.1% of all stones, compared with only 3.2% in the UK cohort ($p<0.0001$).

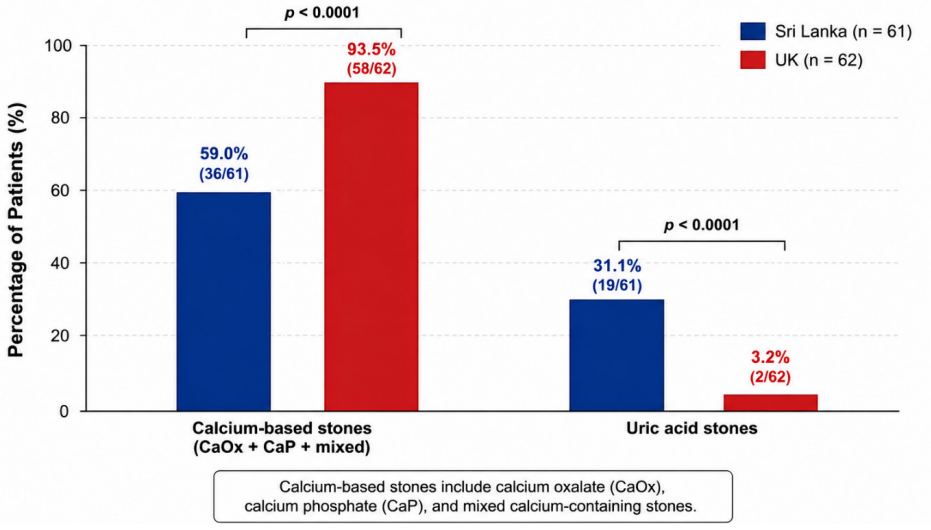


Figure 9. *Comparison of calcium-based and uric acid stones between the Sri Lankan and UK cohorts.*

Overall, these findings demonstrate distinct epidemiological differences in urinary stone composition between the Sri Lankan and UK populations. The Sri Lankan cohort exhibited a more heterogeneous metabolic-infective stone profile, whereas the UK cohort was characterised predominantly by calcium-based urinary stones. These differences may be attributable to variations in environmental exposures, dietary practices, socioeconomic conditions, healthcare access, and underlying metabolic risk factors between the two populations (15-17).

Struvite (infection-related) stones

Struvite stones were observed more frequently in the Sri Lankan cohort than in the UK cohort, accounting for 8.2% and 3.2% of all urinary stones, respectively. Although the difference was modest, it suggests a relatively greater burden of infection-related stone disease among patients in Sri Lanka. When stone composition was reassessed after excluding patients with calcified stents/catheters (n=4) to minimize the potential bias toward a higher proportion of infection stones, 3 of 57 stones (5.2%) in the Sri Lankan cohort were classified as infection stones, compared with 3.2% in the UK cohort.

The higher prevalence of struvite stones in the Sri Lankan cohort may reflect differences in the burden of urinary tract infections, delayed presentation to healthcare services, and disparities in access to healthcare. These factors may contribute to an increased risk of infection-related stone formation within the Sri Lankan population.

Stone composition according to site of origin

Analysis of stone composition according to anatomical site demonstrated distinct differences between the Sri Lankan and UK cohorts. In the Sri Lankan cohort, calcium oxalate stones predominated within the upper urinary tract, whereas uric acid stones were proportionally more common within the lower urinary tract. In contrast, calcium oxalate remained the predominant stone type in both the upper and lower urinary tract in the UK cohort.

Within the Sri Lankan cohort, a statistically significant association was observed between stone composition and anatomical site of origin (χ^2= 8.36, df = 3, p= 0.039). Conversely, no significant association was identified in the UK cohort (Fisher-Freeman-Halton exact test, p>0.05).

These findings suggest that the relationship between stone composition and anatomical site differs between the two populations. The higher proportion of uric acid stones in the lower urinary tract, together with the relatively greater prevalence of struvite stones in the Sri Lankan cohort, may indicate a greater contribution of metabolic and infection-related mechanisms to lower urinary tract stone formation. However, further studies incorporating microbiological and metabolic evaluation are required to confirm these observations.

Sub analysis of calcified stent/catheter stone composition in Sri Lankan cohort

Struvite was the most common constituent, accounting for 50.0% of samples. This finding supports the recognised association between bacterial colonisation, biofilm formation, and the development of infection-related encrustations on indwelling urinary devices (18-20).

The predominance of struvite within these calcifications further suggests that infection-related processes contribute substantially to lower urinary tract calcification in the Sri Lankan cohort.

Conclusion

To our knowledge, this is the first Sri Lankan study to directly compare urinary stone composition between Sri Lankan and United Kingdom cohorts using Fourier-transform infrared (FTIR) spectroscopy. The findings demonstrated significant differences in stone composition between the two populations, highlighting the influence of geographical, metabolic, environmental, and dietary factors on urinary stone disease. Calcium-based stones predominated in the UK cohort, whereas the Sri Lankan cohort exhibited a more heterogeneous stone profile with a significantly higher prevalence of uric acid stones, suggesting differing environmental, metabolic, and dietary influences on stone formation.

Stone composition also varied according to anatomical site in the Sri Lankan cohort, with calcium oxalate stones predominating in the upper urinary tract and uric acid stones occurring more

frequently in the lower urinary tract. No significant anatomical variation was observed in the UK cohort. Struvite was the predominant constituent of calcified ureteric stents and urinary catheters, supporting the role of infection in device-related encrustation.

These findings highlight the importance of population-specific strategies for the prevention and management of urinary stone disease. In the Sri Lankan setting, emphasis should be placed on optimising hydration, early diagnosis and treatment of urinary tract infections, appropriate metabolic evaluation of high-risk stone formers, and timely removal of indwelling urinary devices to reduce infection-related stone formation. Further multi-centre studies incorporating metabolic, micro-biological, and dietary assessment are required to validate these findings.

Acknowledgements

The authors would like to express their sincere gratitude to the patients who participated in this study. We gratefully acknowledge the support and assistance provided by the consultants, medical officers, nursing staff, and theatre staff of the National Hospital of Sri Lanka, Colombo, throughout the study period.

We also thank the staff of the Department of Chemical Pathology, Colombo North Teaching Hospital, for performing the Fourier-transform infrared (FTIR) stone analyses and for their technical support.

Our sincere appreciation is extended to the patients, consultants, nursing staff, and the Department of Urology at Bedfordshire Hospitals NHS Foundation Trust for their guidance, support, and assistance during the UK component of this study. We are also grateful to the Department of Chemical Pathology, University College London Hospitals NHS Foundation Trust, for undertaking the stone compositional analyses.

The authors also wish to express their sincere appreciation to Dr Asaem Chaudry, Senior Consultant Urological Surgeon and Clinical Lead, Bedfordshire Hospitals NHS Foundation Trust, and Dr WAS de Silva, Senior Consultant Urologist, Department of Urology, National Hospital of Sri Lanka, for their invaluable guidance, encouragement, and supervision throughout this study.

Conflicts of interest

The authors declare that there are no conflicts of interest.

References

1. Modlin M. A history of urinary stone. S Afr Med J. 1980; 58: 652-655.
2. Pak CYC. Kidney stones. Lancet. 1998; 351: 1797-1801. doi:10.1016/S0140-6736(98)01295-1.
3. Sorokin I, Mamoulakis C, Miyazawa K, Rodgers A, Talati J, Lotan Y. Epidemiology of stone disease across the world. World J Urol. 2017; 35: 1301-20.
4. Skolarikos A, Neisius A, Pet?ík A, et al. EAU Guidelines on Urolithiasis. Presented at the EAU Annual Congress, Amsterdam. Arnhem: European Association of Urology Guidelines Office.
5. Stoller ML, Meng MV. Urinary Stone Disease: The Practical Guide to Medical and Surgical Management. Totowa, NJ: Humana Press; 2007.
6. Charafi S, Mbarki M, Bauza AC, Prieto RM, Oussama A, Grases F. A comparative study of two renal stone analysis methods. Int J Nephrol Urol. 2010; 2: 469-75.
7. Sarigul N, Kurultak i, Uslu Gökceoglu A, Korkmaz F. Urine analysis using FTIR spectroscopy: A study on healthy adults and children. J Biophotonics. 2021; 14: e202000349.
8. Ansari MS, Gupta NP, Hemal AK, et al. Spectrum of stone composition: Structural analysis of 1050 upper urinary tract calculi from Northern India. Int J Urol. 2005; 12: 12-16.
9. Daudon M, Donsimoni R, Hennequin C, et al. Sex- and age-related composition of 10,617 calculi analysed by infrared spectroscopy. Urol Res. 1995; 23: 319-26.
10. Trinchieri A, Rovera F, Nespoli R, Currò A. Clinical observations on 2086 patients with upper urinary tract stones. Arch Ital Urol Androl. 1996; 68: 251-62.
11. Daudon M, Doré JC, Jungers P, Lacour B. Changes in stone composition according to age and gender of patients: A multivariate epidemiological approach. Urol Res. 2004; 32: 241-7. doi:10.1007/s00240-004-0421-y.

12. Wang S, Zhang Y, Zhang X, Tang Y, Li J. Upper urinary tract stone compositions: The role of age and gender. Int Braz J Urol. 2020; 46: 70-80. doi:10.1590/S1677-5538.IBJU.2019.0278.

13. Lieske JC, Rule AD, Krambeck AE, Williams JC Jr, Bergstralh EJ, Mehta RA, et al. Stone composition as a function of age and sex. Clin J Am Soc Nephrol. 2014; 9: 2141-6. doi:10.2215/CJN.05660614.

14. Hareendra PPGK, Hunais MM, Suvendiran S, Palihakkara SD, Abeygunasekera AM. Chemical composition of kidney stones obtained from a cohort of Sri Lankan patients.

15. Siener R. Nutrition and kidney stone disease. Nutrients. 2021; 13: 1917. doi:10.3390/nu13061917.

16. Trinchieri A. Diet and renal stone formation. Minerva Med. 2013; 104: 41-54.

17. Ferraro PM, Bargagli M, Trinchieri A, Gambaro G. Risk of kidney stones: Influence of dietary factors, dietary patterns, and vegetarian-vegan diets. Nutrients. 2020; 12: 779. doi:10.3390/nu12030779.

18. Bonfitto M, et al. Case Rep Urol. 2019; 2019: 6957141. doi:10.1155/2019/6957141.

19. Aponte V, et al. A novel endoscopic approach for distally calcified ureteral stents.. 2022.

20. Robert M, et al. Urol Int. 1997; 58(2): 100-4. doi:10.1159/000282959.