Case report

A rare pure calcite urolithiasis confirmed by infrared spectroscopy

Abdelaali Belhachem[*,1,2,3], Mustapha Zendjabil[3], Slimane Houache[5], Amina Amiar[2], Houari Toumi[2,4]

[1]*Pharmaceutical Inorganic Chemistry Laboratory, Faculty of Medicine, University of Oran 1, Algeria*
[2]*Pharmacovigilance department, University Hospital Establishment of Oran, EHU-O, Algeria*
[3]*Department of Biochemistry, Oran University Hospital, Oran, Algeria*
[4]*Pharmaceutical Development Research Laboratory, University of Oran 1, LRDP-ORAN, Algeria*
[5]*Private Practice of Urology Oran, Algeria*

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[*]***Author of correspondence:***
Abdelaali Belhachem
E-mail: belhachem.ali87@gmail.com
Tel.: 00213559587473
Address:
Pharmaceutical Inorganic Chemistry Laboratory, Faculty of Medicine, University of Oran 1, Algeria

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This case report describes a 41-year-old woman with no significant medical history and a normal body mass index (BMI), who presented with ureterohydronephrosis due to a 5.5mm x 9mm calculus composed primarily of calcite ($CaCO_3$) at the ureterovesical junction. The kidney stone, associated with cystitis and perirenal fat infiltration, was spontaneously expelled and subsequently analyzed. Optical microscopy revealed a grey homogeneous stone with a rough surface and white crystals upon examination. Fourier-transform infrared spectroscopy (FTIR-ATR) confirmed the stone's composition as pure calcite, displaying characteristic absorption bands indicative of its crystalline structure. The patient reported long-term use of multiple vitamins and plant-based supplements, possibly contributing to stone formation. The discussion includes insights on calcite urolithiasis, highlighting factors such as alkaline urine pH and calcium metabolism that can influence stone formation, underscoring the complexity of managing kidney stone risk in supplement users.

Introduction

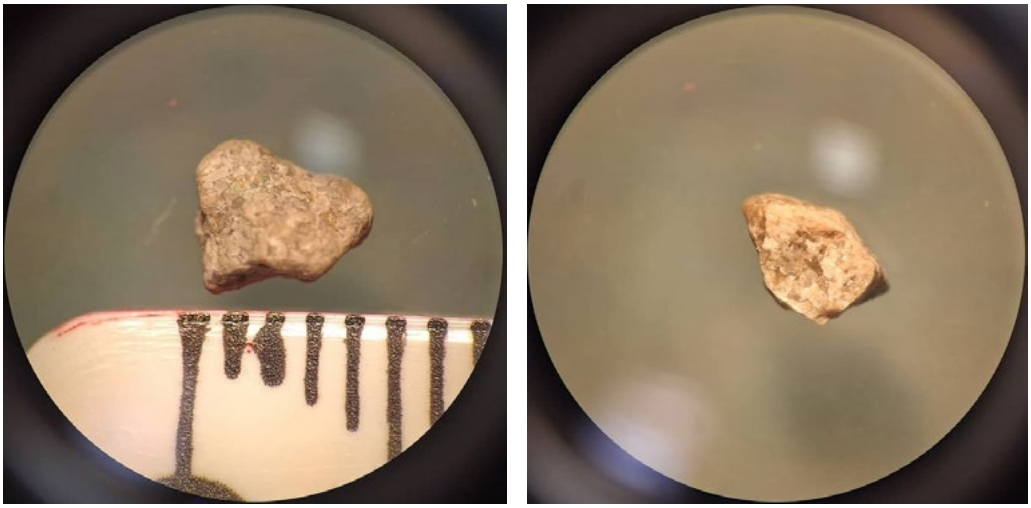
The majority of renal stones are of mixed composition. In humans, the most frequent stone components include calcium oxalate (whewellite [COM] and weddellite [COD]) and calcium phosphate (apatite and brushite) [1,2]. Calcite is rarely considered a true component of a kidney calculus, being present in only 0.01% to 0.25% of all stones, and usually mixed with other components. Calcite, the predominant form of natural calcium carbonate ($CaCO_3$), is renowned for its diverse crystal formations and widespread occurrence in nature. It exhibits polymorphism, with some specimens being nearly pure $CaCO_3$ while others contain varying proportions of additional cations such as Mg, Mn, Fe, B, Br, Sr, and/or Y substituting for calcium [3]. Metastable magnesian calcites, containing approximately 5 to 18% $MgCO_3$, are widespread in biogenic skeletal structures and serve as cement in some modern marine sediments. Calcite is a common earth mineral and the principal constituent in limestone and marble, common in human pancreatic and salivary lithiasis and in equine urolithiasis, but rare in human urolithiasis [4]. Calcite stones presented by patients as spontaneously passed are often artifactual or factitious. The aim of this case study is to outline an uncommon instance of a patient who exhibited a calcite urolithiasis confirmed by infrared spectroscopy.

Case report

A 41-year-old woman with no medical history, having a BMI of 24,91 (height: 170 cm, weight: 72 kg), is considered to be healthy weight. Blood samples tests revealed normal levels of calcium, and normal potassium, sodium, magnesium, phosphate, creatinine, and urea. The patient's history revealed that she took multiple vitamins during pregnancy and for more than three years afterward. She also took plant-based dietary supplements to promote vasodilation, aiming to enhance oxygen and nutrient delivery to the placenta and the developing foetus. The uro-CT scan shows the left kidney with dilation of all excretory cavities up to its terminal portion upstream of a 5.5mm x 9mm calculus (ureterohydronephrosis) with a density of 930 Hounsfield Units, lodged at the ureterovesical junction. It is associated with cystitis and a slight infiltration of the perirenal fat. The kidney stone is spontaneously expelled.

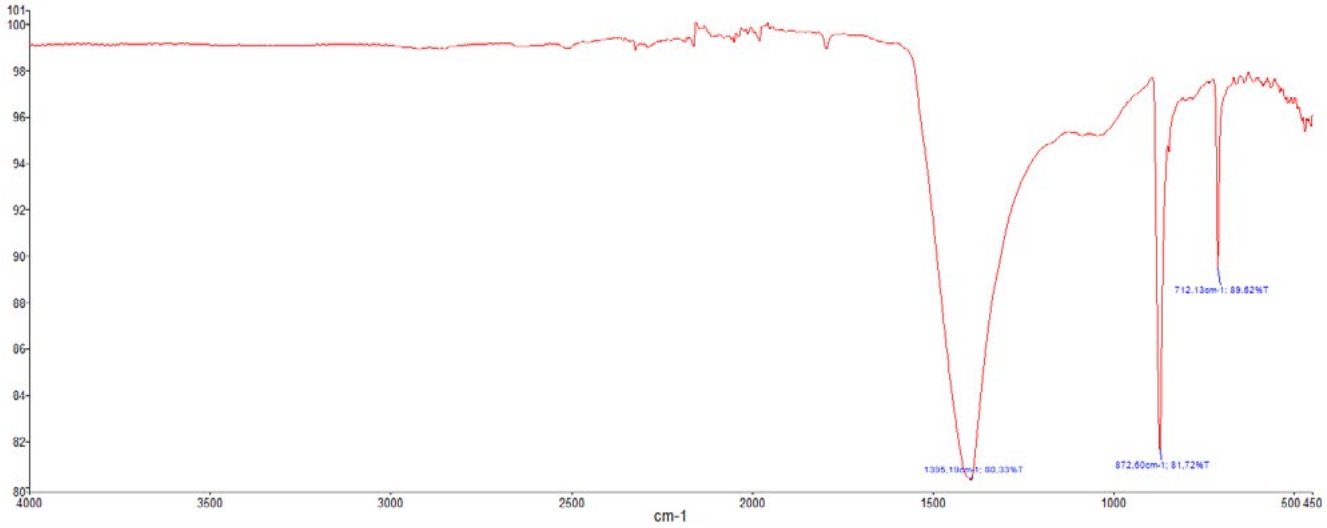
The stone weighed of 0,05g and was observed under an optical microscope (Gx10x40) to examine the morphology of the surface and section. The stone appeared grey and homogeneous with a rough surface containing white crystals. The cross-section was found to be crystalline, compact, and dense (Figure 1).

Figure 1: Surface and section of the calculi under optical microscope (10*40).



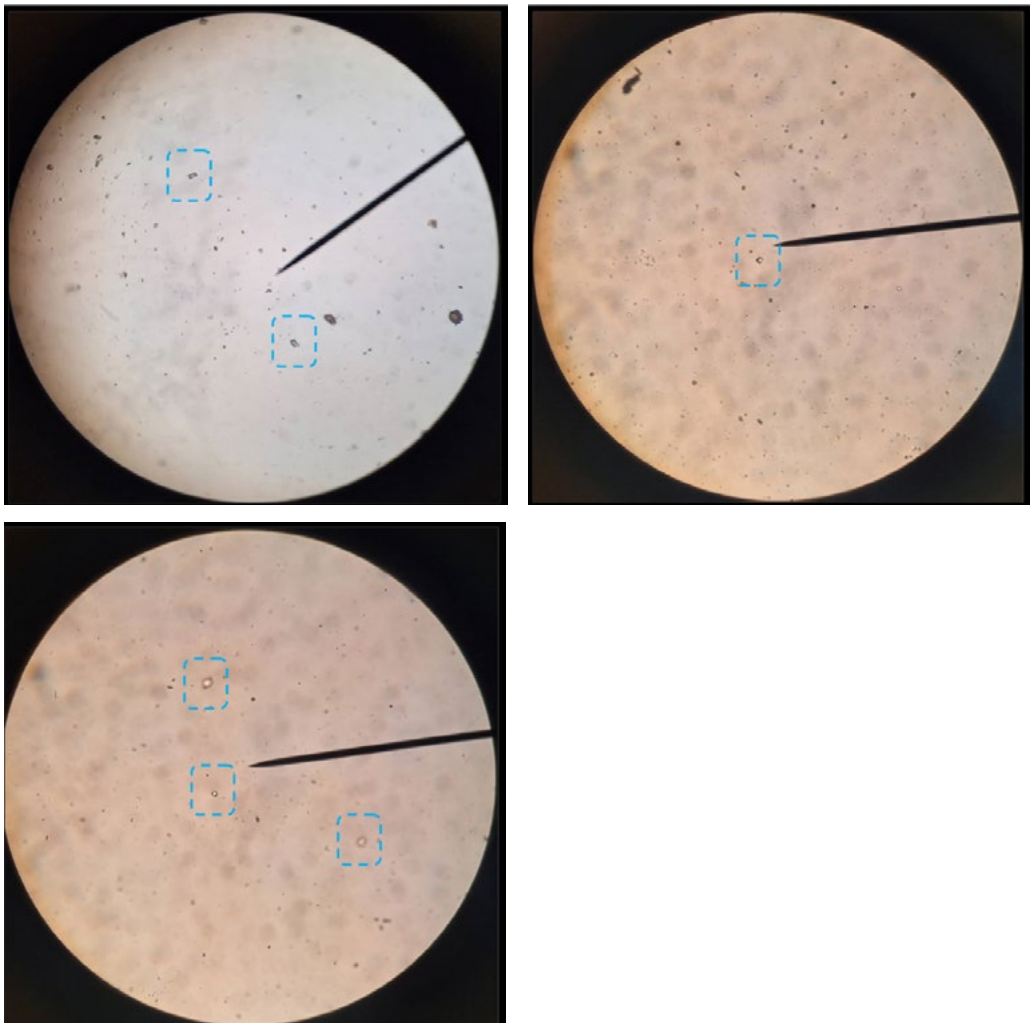
The infrared spectra were obtained using Fourier transform infrared spectroscopy coupled with attenuated total reflection (FTIR-ATR) (Perkin Elmer, Shelton, CT, USA) within the range of 450–4000 cm^{-1}. The absorption spectrum acquired is indicative of the molecular composition and potential crystalline structure of the sample (Figure 2). A strong absorption band was observed around 1395 cm^{-1}, corresponding to C=O stretching. Medium to strong absorption bands were noted near 872 cm^{-1} and 712 cm^{-1}, attributed to C-O stretching and CO_3 out-of-plane bending. Additionally, low-frequency bands below 700 cm^{1} were detected, associated with lattice vibrations of the calcite crystal structure. In summary, the precise positions and intensities of these bands confirm the stone's composition and purity as calcite, primarily composed of calcium carbonate ($CaCO_3$).

Figure 2: FTIR spectrums of the kidney stone.



Some of the calculi were dissolved in pure water and examined under a microscope to search for crystals (Figure 3). The crystals were observed as needle-like or prismatic structures, as well as envelope-shaped or elongated structures with pointed ends and a light brown color.

Figure 3: Crystals under optic microscope (G*100).



Discussion

Often, when calcite is found as a component of urinary calculi, it is considered false calculi or artifacts [5]. In this case, renal calculi were obtained following spontaneous elimination, after which a second computed tomography (CT) scan revealed left kidney pyelocaliceal cavity dilation and absence of the calculi. Similar to a case previously reported in a 42-year-old woman with anorexia since adolescence and a 5-year history of recurrent nephrolithiasis [6]. In that case, stone analysis from both sides using IRS revealed pure calcite ($CaCO_3$). In an Egyptian study of pediatric nephrolithiasis, calcite was found in 10% of cases; however, the underlying causes of calcite stone formation were not discussed [7]. The underlying cause of calcite urolithiasis is unclear. Calcium carbonate is frequently identified as a constituent of "milk of calcium" stones, occasionally forming as partially calcified fluid accumulations within obstructed areas of the upper urinary collecting system, including cases of hydronephrosis [8,9]. In Gault's study, a number of patients were diagnosed with medullary sponge kidney, prompting his hypothesis that elevated urine concentrations of bicarbonate, carbonate, or calcium in an alkaline pH environment were significant factors. Additionally, Gault conducted experiments demonstrating that calcite stones dissolved in vitro at a pH of 5.0 but remained stable at 6.5, indicating their susceptibility to dissolution in an acidic environment [10]. CT imaging and direct visualization of this patient's kidney demonstrated no evidence of medullary sponge kidney; however, her initial CT demonstrated ureterohydronephrosis to the obstructing stone. According to a Swedish cohort study, the risk of kidney stones would double in men taking dietary supplements of vitamin C. Without questioning the health benefits of this vitamin, these findings underscore the importance of adhering to recommended daily doses to limit the risk of overdose. The ascorbic acid found in urine corresponds to the unmetabolized portion, but it can also be excreted in urine in the form of oxalate and, to a lesser extent, in the respiratory system as CO_2. In this case, the overconsumption of multivitamins over the years may have caused the kidney stone formation. Herbal supplements can impact the formation of calcium carbonate kidney stones in several ways [10,11]. Certain herbs possess alkalizing properties that elevate urinary pH levels, potentially promoting the precipitation of calcium carbonate in urine, which is particularly relevant for individuals prone to alkaline stone formation. Additionally, some herbal supplements can interact with calcium metabolism, altering its absorption, excretion, or utilization in the body. These interactions may indirectly influence the risk of calcium stone formation by affecting the balance of calcium ions available for crystallization in the urinary tract. Therefore, caution is advised when considering herbal supplementation, especially for individuals at risk of calcium carbonate kidney stones, to mitigate potential effects on stone formation [12].

Conclusion

This case underscores the complexity of kidney stone formation and the potential role of long-term vitamin and herbal supplement use in predisposing individuals to calcite urolithiasis. The spontaneous expulsion of a calcite stone in this otherwise healthy woman, coupled with the absence of medullary sponge kidney, suggests a multifaceted etiology potentially influenced by dietary habits. The presence of alkaline urine pH and interactions with calcium metabolism are critical considerations in understanding stone formation mechanisms. Clinicians should remain vigilant in assessing dietary supplement histories and educating patients on adhering to recommended doses to mitigate the risk of stone recurrence. Further research is warranted to elucidate specific risk factors and preventive strategies tailored to individuals susceptible to calcium carbonate kidney stones.

Declarations

Ethical approval and Consent to Participate

It were not required for this kidney stone analysis as it involved the use of previously collected and anonymized clinical data. The research that involves the analysis of existing, de-identified data, without any direct patient interaction or intervention, does not necessitate ethical approval.

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Author contributions

AAB, MZ, SH, and AA carried out the study, designed and conducted all laboratory analyses, interpreted experimental results, and prepared the manuscript. HT supervised the study.

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Availability of data and materials

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Consent for publication

All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Declaration

During the preparation of this work, the authors used OpenAI's language model (Chat GPT and WordVice) in order to enhance the clarity and coherence of the manuscript. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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