Case report

Spontaneous expulsion and compositional analysis by infrared spectroscopy of a parotid sialolith: a case report

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Abstract

Introduction: Sialolithiasis, or salivary gland stone formation, is a condition characterized by mineralized deposits in the salivary ducts. This case report highlights the clinical presentation, spontaneous expulsion, and compositional analysis of a salivary stone in a 35-year-old North African male.

Case Presentation: A patient with no significant medical history or dental issues presented with a spontaneously expelled salivary stone during a salty meal. The stone, measuring 13 mm and weighing 0.52 g, caused mild pain in the left parotid gland during salty and sour meals. Laboratory tests revealed normal calcium and electrolyte levels. The stone was examined using optical microscopy and Fourier transform infrared spectroscopy (FTIR-ATR), confirming its composition as carbonated apatite with minor organic content.

Discussion: The formation of sialoliths is attributed to salivary stasis and altered salivary composition, promoting calcium phosphate precipitation. FTIR-ATR analysis demonstrated a structure composed of concentric layers of carbonated apatite, indicating progressive mineralization. Smoking and glandular physiology, including higher calcium content and pH in parotid saliva, were likely contributors. Management strategies for sialolithiasis emphasize conservative measures, with surgical intervention reserved for larger stones.

Conclusion: This case underscores the complex interplay of local and systemic factors in sialolith formation. The detailed compositional analysis enhances understanding of pathogenesis, aiding in improved diagnostic and therapeutic approaches for salivary stones.

Introduction

Sialolithiasis is the most common disorder of the salivary glands, affecting approximately 1.2% of the adult population, with a slight male predominance. This condition is characterized by the formation of calcified deposits, known as sialoliths, within the ductal system or parenchyma of the salivary glands, most frequently in the submandibular gland (80% of cases). Sialoliths can obstruct salivary flow, leading to painful swelling, particularly during mealtime, due to increased intraglandular pressure. The typical size of sialoliths ranges from 1 mm to 1 cm, with rare instances exceeding 1.5 cm, and even fewer documented cases reaching the size threshold of 3.5 cm or larger [1] [2]. The rarity of giant sialoliths makes them significant in clinical practice, as they can present unique challenges in diagnosis, treatment, and management.

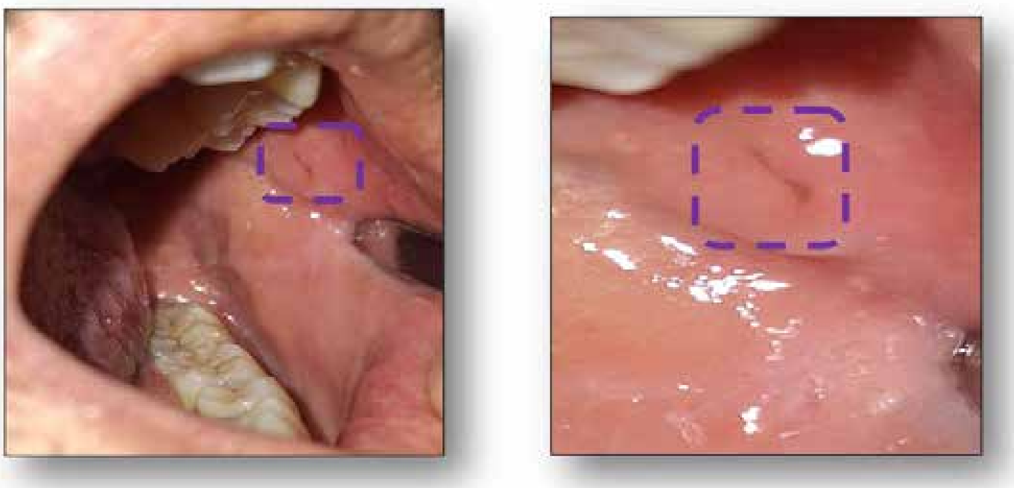
Salivary stones typically appear yellow or yellow-brown and can vary significantly in both size and weight, ranging from 1 mg to nearly 6 g, with an average weight of approximately 300 mg. Submandibular stones are generally larger than those found in the parotid gland. The shape of a sialolith often depends on its origin; stones from the ductal system tend to be elongated, while those from the hilus or gland are more rounded or oval. Additionally, submandibular stones usually have a smoother surface, whereas parotid stones are often more irregular in shape [3] [4].

Sialoliths are composed of both organic and inorganic materials, with a variable ratio between the two. Unlike submandibular stones, which expel more frequently due to anatomical factors, parotid stones rarely expel spontaneously, occurring in less than 10–15% of cases. The majority of parotid stones must be removed surgically or by sialendoscopic means. The organic matrix, which constitutes 23-100% of the stone, is primarily located in the nucleus and outer shell. Inorganic components are predominant, particularly in submandibular stones, where they account for 70-80% of the composition, compared to approximately 50% in parotid stones [4] [2]. Mineralization increases with stone size, indicating a gradual accumulation of minerals within the organic matrix. Hydroxyapatite ($Ca_5(PO_4)_3OH$) is universally present in submandibular stones, often accompanied by whitlockite ($Ca_3(PO_4)_2$), which is commonly found in stones from Wharton's duct. Parotid stones also consistently contain hydroxyapatite, with whitlockite and octacalcium phosphate observed more frequently than in submandibular stones [5] [6].

Case report

A 35-year-old North African male patient, with no significant medical or dental history, presented with a body mass index (BMI) of 26.37 (height: 172 cm, weight: 78 kg), categorizing him as overweight. The patient spontaneously expelled a salivary stone while consuming a salty meal, with the calculus migrating through the left parotid duct due to the pressure from saliva secretion. Post-expulsion imaging (Figure 1) revealed dilation of the affected duct. Laboratory analyses were within the reference interval levels in plasma of calcium, potassium, sodium, magnesium, phosphate, creatinine, and urea. The patient's history indicated that he is a smoker and reported experiencing intermittent pain in the left parotid gland, particularly during the consumption of salty or sour foods. A follow-up consultation three months later with an otolaryngologist revealed no clinical signs of sialolith formation or infection in the parotid region. Notably, the patient reported complete resolution of symptoms, including the absence of pain during sour food consumption. These findings, along with normal blood laboratory results, suggest spontaneous elimination of the salivary stone.

Figure 1: Post-elimination dilation of the left salivary parotid duct.



The stone weighed 0.52 g and measured 13 mm. It was observed under an optical microscope (Gx10x40) to examine the morphology of its surface and section, as shown in (Figure 2).

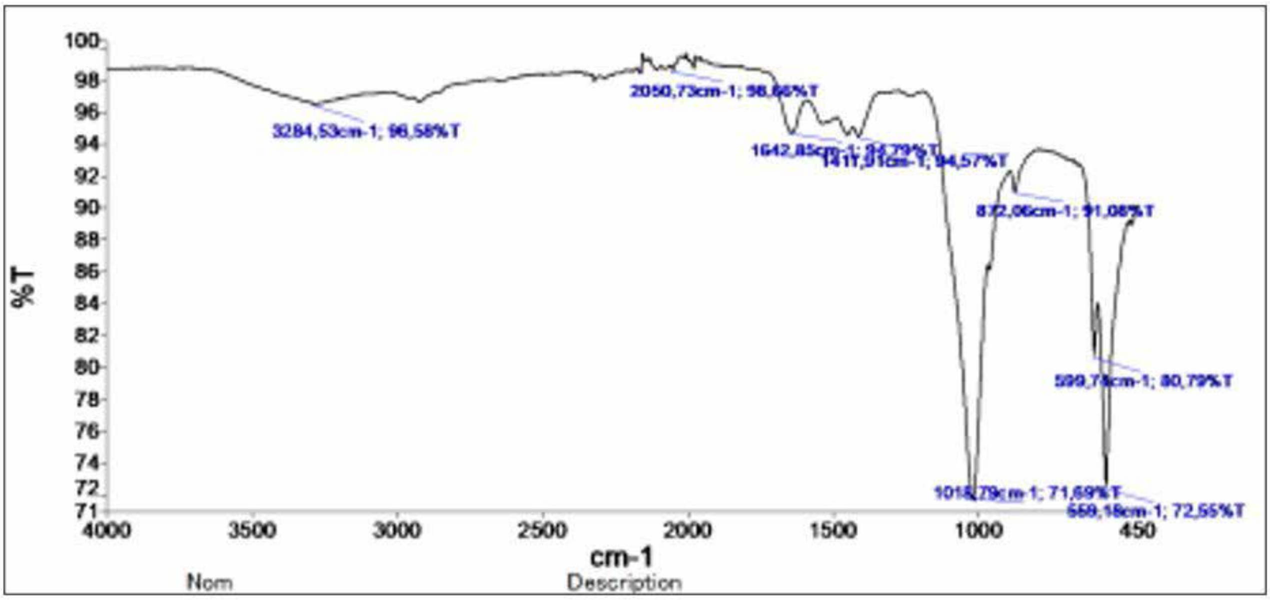
Figure 2: Surface and section of the stone under optical microscope (10*40).

The sialolith exhibits an oval to rounded shape with a nodular surface texture, indicative of mineral deposition. Its color ranges from white to yellowish, with a beige to pink central hue. Internally, the stone displays concentric layers that resemble rings, suggesting a gradual accumulation of minerals over time. These concentric formations are characteristic of the stone's progressive growth. The center, often referred to as the nucleation point, presents a distinct texture and color, representing the initial site of formation where mineralization commenced. Overall, the texture of the stone is smooth.

The infrared spectra were obtained using Fourier transform infrared spectroscopy coupled with attenuated total reflection (FTIR-ATR) (PerkinElmer, Shelton, CT, USA). The stone was first rinsed with distilled water to remove surface contaminants, then air-dried at room temperature. Using an agate mortar and pestle, the dried sample was ground into a consistent powder. To guarantee spectral reproducibility and accuracy, three consecutive scans were averaged for each measurement, and spectra were recorded in the 4000–500 cm^{-1} range with a spectral resolution of 4 cm^{-1}.

The FTIR-ATR spectrum of sialolith reveals key features characteristic of its composition. A broad peak at 3284 cm^{-1} corresponds to hydroxyl group stretching (–OH), while a peak at 2909 cm^{-1} suggests the presence of trace organic material (C–H). The strong peak at 1642 cm^{1} indicates bending vibrations of molecular water, highlighting hydration. Peaks at 1412 cm^{1} and 872 cm^{1} are attributed to carbonate ions ($CO_3 3^{2-}$), confirming the carbonated nature of the apatite. Additionally, prominent peaks at 1012 cm^{-1}, 599 cm^{1}, and 569 cm^{1} represent phosphate ion (PO_4^{3-}) vibrations typical of biological apatite. These spectral features confirm the stone's composition as carbonated apatite, with hydration and minor organic content, consistent with sialolith formation via mineral precipitation and organic matrix incorporation in the salivary ducts (Figure 3).

Figure 3: FTIR-ATR spectrums of the salivary stone.



Discussion

The clinical formation of this salivary stone composed of carbonated apatite, as confirmed by FTIR-ATR analysis, aligns with the typical pathogenesis of sialoliths [2]. The process begins with salivary stasis or reduced salivary flow within the ducts, often caused by inflammation, ductal obstruction, or altered salivary composition [7]. This stagnation facilitates the precipitation of calcium and phosphate ions, which combine to form hydroxyapatite [8]. In biological systems, carbonate ions frequently substitute into the hydroxyapatite lattice, resulting in carbonated apatite, a mineral commonly found in salivary stones [9].

The nucleation of a stone begins around an organic core, typically composed of mucus, cellular debris, or bacterial colonies, which serves as a scaffold for mineral deposition. Over time, layers of carbonated apatite accumulate concentrically, as indicated by the FTIR-ATR spectrum [10]. Hydration and minor organic components further promote the growth and stabilization of the stone. The formation of these stones reflects a combination of local environmental changes in the salivary ducts and systemic factors that influence mineral metabolism [11].

Parotid saliva has a higher pH and contains twice the amount of calcium compared to saliva from other glands, both of which support mineralization [12]. The elevated pH reduces the solubility of calcium phosphate, promoting the formation of a mucoid gel that can calcify within the ductal system [7]. This mineralization can obstruct the duct, leading to pain, swelling, and decreased saliva production, with symptoms often worsening during meals [13]. The accumulation of saliva can lead to infection and inflammation of the gland, a condition known as sialadenitis. Treatment options may include hydration, gland massage, or, if conservative methods prove ineffective, surgical removal of the stone [14].

The formation of sialolithiasis is influenced by both local and systemic factors. Altered saliva composition, characterized by increased protein content, viscosity, and calcium concentration, along with reduced levels of crystallization inhibitors such as phytate, magnesium, and citrate, plays a critical role in promoting mineralization [15]. Systemic factors such as gout and the use of diuretics, which decrease salivary flow, further predispose individuals to the formation of stones [13]. Smoking may exacerbate bacterial colonization and inflammation; however, its role in the development of salivary stones remains uncertain [16]. Interestingly, the relationship between salivary stones and systemic conditions such as diabetes, hypertension, kidney stones, and gallstones is inconsistent, warranting further investigation [17]. Structurally, sialoliths consist of a mineralized core surrounded by concentric layers of organic and inorganic materials, with their formation likely occurring intermittently [18]. The biochemical composition reveals a predominance of calcium phosphates in the inorganic matrix, while the organic matrix comprises proteins, lipids, and carbohydrates. Notably, submandibular stones exhibit distinct differences in the proportions of organic materials compared to parotid stones [19]. Our results were contrasted with comparable cases reported in the literature, such as a 4 mm stone extruded via skin ulceration and an 11 mm parotid stone expelled through a cutaneous fistula Furthermore, thorough FTIR-ATR analysis yielded accurate compositional insights that had not been documented in earlier research [13].

Management of sialolithiasis focuses on preserving gland function and minimizing discomfort. Small, ductal stones are often treated conservatively through gland massage, sialogogues, and irrigation, while larger or more complex stones may require transoral surgical removal or advanced techniques such as lithotripsy or sialoendoscopy [14]. Post-treatment care, including gland massage and a sour diet, is essential for stimulating salivary flow and reducing recurrence rates, which remain low at 1–10% [8]. The ability of glands to recover function post-treatment depends on factors such as infection, stone size, and patient age [20]. Despite advances in minimally invasive procedures, further research into the mechanisms of stone formation and tailored treatment approaches could enhance patient outcomes.

Conclusion

This case highlights the spontaneous elimination of a salivary stone in a 35-year-old male patient, offering valuable insights into the pathogenesis, composition, and management of sialolithiasis. The stone, composed of carbonated apatite, exemplifies the typical structural and biochemical characteristics of salivary stones, including concentric layers and a hydrated organic matrix, as confirmed by FTIR-ATR analysis. Local factors, such as elevated salivary pH and calcium concentration in the parotid gland, along with systemic influences like smoking, likely contributed to its formation. Management in this case was non-invasive, with spontaneous stone expulsion facilitated by salivary stimulation during a salty meal. This outcome underscores the potential of conservative measures for small ductal stones while emphasizing the necessity of regular follow-up to monitor gland function and prevent recurrence. The findings further support ongoing research into the multifactorial mechanisms of sialolith formation and the development of optimized, patient-specific treatment protocols.

Statements and Declarations

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Competing interests

The authors declare that they have no competing interests.

Author contributions

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

Consent for publication

All authors read and approved the final manuscript.

Ethical approval and Consent to Participate

It was not required for this salivary 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.

Consent to participate

Informed consent was obtained from the patient included in the study.

Consent to publish

The authors affirm that human research participant provided informed consent for publication of the images in Figures 1, 2 and 3.

Clinical trial number

Not applicable.

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Code Availability

This study did not use any custom code or software.

Availability of data and materials

NA.

Declaration

During the preparation of this work, the authors used OpenAI's language model (ChatGPT 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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