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Salivary Gland Stones in the Mouth: Pathophysiology, Diagnosis, and Modern Treatments

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Abstract

Salivary gland stones (sialoliths) are among the most common disorders of the salivary glands, formed by the crystallization of minerals, especially calcium, within the salivary ducts. These stones most frequently affect the submandibular glands (70-80%), followed by the parotid glands (20%), and rarely other glands. Symptoms include intermittent painful swelling, particularly during meals. Diagnosis is based on clinical examination and imaging techniques such as ultrasound, CT scan, and sialendoscopy. Treatment varies from conservative measures to surgical intervention, depending on the size, location, and number of stones. This article provides a comprehensive review of the formation mechanisms, modern diagnostic methods, and current treatment options, with an emphasis on minimally invasive approaches.

Introduction

The salivary gland system consists of the major glands (parotid, submandibular, sublingual) and hundreds of minor glands, which secrete approximately 0.5-1 liter of saliva daily. In addition to its role in digestion, saliva contains antibacterial agents, buffers, and essential minerals for oral health. Salivary stones form when the balance between minerals and crystallization inhibitors in saliva is disrupted. The prevalence of this condition is reported to be about 1-2% in the general population, with a higher incidence in men aged 30-50. Risk factors include dehydration, use of medications that reduce saliva flow, systemic diseases such as gout and diabetes, and a history of head and neck radiotherapy [1-4].

Clinical Presentation and Diagnostic Methods

Clinical Manifestations

Intermittent painful gland swelling (obstructive sialadenitis). Severe pain during salivary stimulation ("meal-time syndrome"). Palpable mass along the duct course. Reduced or absent saliva flow from the duct, Signs of secondary infection: fever, erythema, purulent discharge. In chronic cases: progressive gland atrophy [2,5].

Diagnostic Methods

Physical Examination: Palpation of the gland and duct, assessment of saliva flow. Ultrasound: Primary non-invasive method with high sensitivity (85-95%). Contrast-enhanced CT Scan: Gold standard for small stones and precise localization. MRI and MR Sialography: Simultaneous evaluation of stone and gland parenchyma. Conventional Sialography: For specific cases and prior to certain treatments. Sialendoscopy: Simultaneous diagnostic-therapeutic approach with direct visualization. Panoramic Radiography: For large, densely calcified stones [1,6,7].

Search Criteria

For this systematic review, searches were conducted in PubMed, Embase, Scopus, Web of Science, and Persian databases such as SID and MagIran using the following keywords: Articles published between 2010 and 2025 Types of studies: Clinical trials, systematic reviews, meta-analyses, and cohort studies.

Pathophysiology and Epidemiology

Stone Formation Mechanisms

The formation of salivary stones is a multi-stage, complex process that requires the examination of several factors:

i. **Nucleation and Initial Growth**: Salivary stones typically form around an organic nidus, which may include: Desquamated epithelial cells· Bacteria (primarily streptococci and staphylococci). Thickened mucus. Cellular debris These nuclei act as a platform for the deposition of hydroxyapatite crystals [$Ca_{10}(PO_4)_6(OH)_2$].

ii. Factors Affecting Crystallization:

a) High Calcium Concentration: Submandibular gland saliva contains twice the calcium concentration of parotid saliva.

b) Alkaline pH: The alkaline environment of submandibular saliva (pH=7.4-7.8) compared to parotid (pH=6.8-7.2) creates more favorable conditions for calcium crystallization

Reduction of Natural Inhibitors: Phosphopeptides, statherins, and citrates that normally prevent crystallization· High Viscosity: Thick mucous secretions in the submandibular gland. Anatomical Factors: Duct Length: Wharton's duct in the submandibular gland is about 5 cm long, while Stensen's duct in the parotid is about 3cm· Duct Direction: The submandibular duct opens upward against gravity Duct Diameter: Variations in duct diameter create stagnant areas [8,4,9].

Epidemiology and Distribution:

a) Gland Distribution: Submandibular (68-84%), Parotid (10-20%), Sublingual and minor glands (1-2%)

b) Gender Distribution: Male to female ratio approximately 1.5:1 Age of Peak Incidence: 30-50 years

c) Stone Location: 70% in main ducts, 20% in the gland hilum, 10% in the parenchyma·

d) Stone Size: From a few millimeters to several centimeters (average 5-8 mm)

e) Modifiable and Non-Modifiable Risk Factors: Non-modifiable: Age, sex, congenital ductal abnormalities · Modifiable: Chronic dehydration, tobacco use, anticholinergic medications, high-calcium diet, poor oral hygiene [10,11].

i. Differential Diagnosis and Modern Treatments

Differential Diagnoses Salivary stones must be differentiated from the following: Salivary Gland Tumors: Gradual growth without relation to meals. Acute Bacterial Sialadenitis: Sudden swelling with severe systemic symptoms. Systemic Inflammatory Diseases: Sarcoidosis, Sjögren's disease. Lymphadenopathy: Swelling of adjacent lymph nodes. Ductal Cysts: Usually soft and compressible

ii. Modern Diagnostic Algorithm

i. Initial Evaluation: Physical examination + Ultrasound

ii. Confirmation of Diagnosis: CT scan for small stones or complex locations

iii. Gland Function Assessment: MR sialography or nuclear scan

iv. Simultaneous Diagnosis and Treatment: Sialendoscopy

Modern Treatment Options 1. Conservative and Minimal Intervention Treatments: Salivary Stimulation: Lemon, sugar-free sour candies, sialogogues (pilocarpine)· Transductal Massage: Gentle pressure toward the duct opening. Stone Hydrolitholysis: Intracanal irrigation with solvent solutions. Minimally Invasive Methods: Sialendoscopy: A revolution in salivary stone treatment· Semi-flexible endoscopes with diameters of 0.8-1.6 mm· Success rate of 75-85% for main duct stones· Complications less than 5% (temporary edema, duct perforation)· Extracorporeal Shock Wave Lithotripsy (ESWL): Suitable for large parotid stones (8-15 mm)· Success rate of 60-70% after 3-5 sessions· Complications: Local hematoma, mild pain · Endoscopic Basket Retrieval: For mobile stones in the duct· Intracorporeal Lasers: Holmium or carbon dioxide for stones attached to the duct wall. Surgical Treatments: Transoral Stone Removal: For stones in the distal portion of the submandibular duct· Preservation of gland function in 95% of cases· Sialodochotomy: Removal of part of the duct along with the stone· Complete Gland Removal (Sialadenectomy): Indications: Multiple intraparenchymal stones, recurrent infections, failure of minimally invasive treatments· Potential complications: Facial nerve damage, Frey's syndrome, local numbness. Combined Approaches: Sialendoscopy with Open Surgery: For large stones or complex locations· Laser with Sialendoscopy: Increases success rate to 90% Challenges and Special Considerations· Intraparenchymal Stones: Require a more aggressive approach· Disease Recurrence: Recurrence rate of 5-10% within the first 5 years· Preservation of Gland Function: A priority of modern treatments· Cost-Effectiveness: Minimally invasive treatments are more cost-effective in the long term [12].

Conclusion

Salivary gland stones are a common disease with a significant impact on patients' quality of life. A deep understanding of the pathophysiology and risk factors enables primary and secondary prevention. Recent developments in imaging techniques, especially high-resolution ultrasound and multi-slice CT scans, have significantly increased diagnostic accuracy. A true revolution in treatment has occurred with the advent of sialendoscopy and other minimally invasive methods, which allow for the preservation of gland function and reduced complications. The treatment algorithm should be tailored based on individual patient characteristics, stone size and location, and available equipment. The future of salivary stone treatment will focus on the further development of endoscopic methods, more effective solvent materials, and a deeper understanding of stone formation biology. Patient education regarding adequate hydration and oral care plays a key role in preventing recurrence.

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