

## Introduction

Previous studies have shown ultrasound is a great tool for evaluation of sialolithiasis with high sensitivity and specificity, but report it to have a tendency to overestimate the actual measurements of stones. This overestimation becomes even more pronounced for stones of smaller diameter (< 5 mm). [2, 3] However, not many studies have been performed to quantify the accuracy of ultrasound when measuring salivary gland sialoliths. Most of the literature studies have been performed while studying kidney stones.

Some present the possibility that this overestimation could be related not to the ultrasound capabilities, but rather to other factors that might interfere and contribute to the overestimation. It is possible that these characteristics affect only the measurements when evaluating kidney stones and will not play a role when evaluating the salivary glands.

Possible culprits for this interference are the depth of the stones, (distance between the probe and the stone) as well as the density of the tissues located between the probe and the stone. When evaluating kidney stones, structures other than the kidney and ureters might interfere and get in the way of the evaluation (bone, bowel, air within the bowel, etc.). These variables are not present during ultrasound evaluation of submandibular or parotid sialoliths, and the distance between probe and structures is much smaller, increasing the frequency and resolution of the evaluation. For these reasons we believe ultrasound will provide a more accurate measurement of sialoliths with less overestimation than the previously demonstrated for urolithiasis.

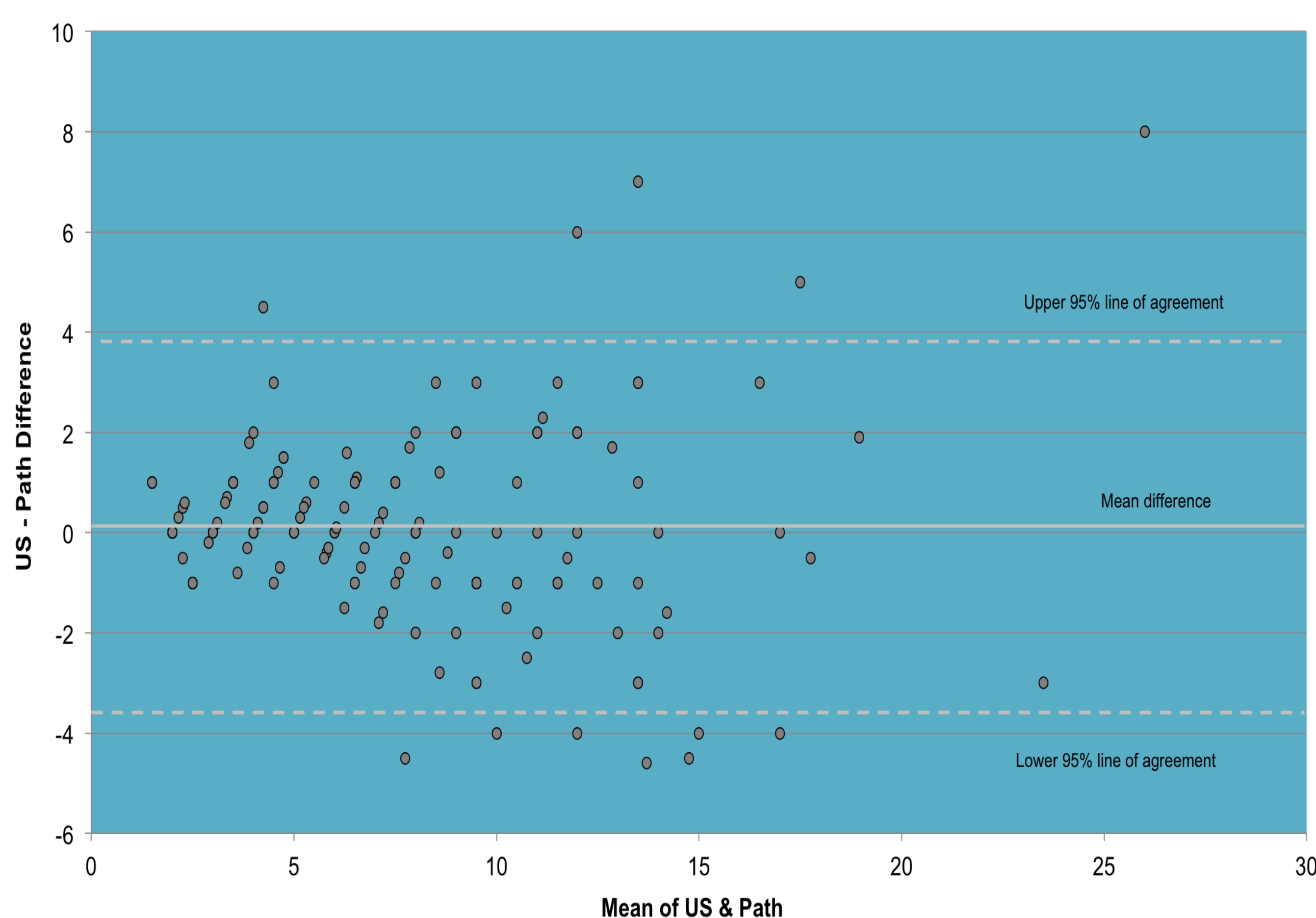
## Methods and Materials

We evaluated stone measurements and ultrasound examinations of 167 patients who underwent treatment of sialolithiasis involving the parotid and submandibular glands. Measurements were collected from ultrasound evaluation before sialolithotomy as well as pathology measurements taken after removal utilizing the same instruments and technique. Ages went from 5 to 84 with an average of 48; 76 of them males, 91 females.

## Results

Calculi were studied in 167 patients. The data was analyzed using Pearson correlation and a Bland-Altman plot. Good concurrent validity was suggested by a Pearson correlation between pathology and ultrasound measurements of 0.92, with a mean difference of 0.095 (p=.51 on a 2-tailed, 1-sample t-test). On the Bland-Altman plot, the correlation between the difference between ultrasound and pathology measurements and their mean is -.01. There were few positive outliers, indicating overestimation by ultrasound. These measurements indicated the mean difference is 0.1 mm (95% ci -0.19 to 0.38).

## Bland – Altman plot for Path vs US measurements



## Discussion

Not many studies have been performed to measure the accuracy of ultrasound when measuring salivary gland sialoliths. Most of the literature studies have been completed for studying kidney stones and have reflected a tendency of ultrasound to overestimate the measurements of stones. [1, 2, 4] Other studies however, think this might be to external factors that might contribute to this reported overestimation. Some studies show smaller stones (< 5 mm) and deeper locations decrease the capacity of ultrasound to provide accurate measurements without overestimation. [2, 5] Skin-stone distance has shown to be an important factor of error in Ultrasound measurement of renal calculi. [2] Overestimation increased an average of 22% with every 2 cm increase in depth. [3] This percentage can also rise with increasing depth and gain of the Ultrasound. [3] Kishore et al. demonstrated a mean overestimation of 1.1 mm when comparing the true stone size of distal ureteral stones that were passed to CT measurements [6] Eisner et al. found that stones were underestimated on CT by as much as 1.9 mm. [7]

The average anatomical distance from skin to SMG is 2-3 cm. For this reason the component of overestimation will be greatly decreased if not completely eliminated when evaluating the salivary glands. A different study found that when comparing the average largest stone diameter for ultrasound vs. non-contrast CT, Ultrasound overestimated stone size by 2.2 mm [8] in 84.6% for stones ≤ 5 mm, 27.1% for stones 5.1-10 mm, and only 3.0% for stones >10 mm, confirming that overestimation increases in smaller size stones.

Our results reported only 3 positive outliers indicating overestimation and the mean difference was only of 0.1 mm, significantly less than in the other studies. There was also good concurrent validity suggested by a Pearson correlation between pathology and ultrasound measurements.

In different studies ultrasound sensitivity fluctuates between 70 – 94% and specificity between 80 – 100%. [9] [4] [1] Overestimation is important given that a difference of 1 or 2 mm can shift the management approach for treatment. Several factors may affect ultrasound diagnosis and interpretation of stone size in urolithiasis. These including the presence of hydronephrosis, stones abutting renal sinus fat, the presence of vascular calcifications, and the presence of bowel gas, which may obscure ureteral calculi, resulting in the previously documented overestimation. [2] However, none of these factors are relevant when evaluating salivary glands. This has been reflected in the results we obtained.

Expertise of the sonographers in evaluations on the area under study has also been documented to contribute to the improved detection rate in the different studies. [16]

In general, CT scan remains the first line for sialoliths evaluation, as many professionals do not perform ultrasound evaluations in the office. From an overestimation standpoint, some studies reports an average overestimation of 1.5 -2 mm in stones measured by US vs CT. [2, 4] Nonetheless, stone size was concordant in 79% of cases between both studies. A positive correlation found between stone sizes measured by US and CT, suggests that US is equally useful for the detection of stones and can aid in making clinically important decisions concerning stone diagnosis. [16] Our goal is to help improve and modify this practice as some studies have shown Ultrasound can identify more effectively superficial foreign bodies than CT scan or conventional radiology does. [8, 16] We believe the superficial location of the salivary glands make them great candidates for a very accurate evaluation and reliable information to be obtained from an ultrasound evaluation. This can be achieved with a lower cost and no exposure of the patient to ionizing radiation. In addition, ultrasound makes it possible to differentiate calcifications in lymph nodes and phleboliths in the lingual veins from salivary sialoliths with a reported accuracy for assessment of sialolithiasis being approximately 90%. [9, 17] [18] It is commonly available, inexpensive to operate and poses no risk of radiation exposure.

## Conclusions

Ultrasound exposure is a highly accurate, minimally invasive, imaging tool for salivary gland sialolithiasis. Preoperative size of calculi can be reliably used to guide management.

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