Medical Ultrasonography
2011, Vol. 13, no. 4, 292-295

Nasal Bone Fracture – Ultrasonography or Computed Tomography?

Afshin Mohammadi[1], Mohammad Ghasemi-Rad[2]

[1] Department of Radiology, Urmia University of Medical Sciences, Urmia, West-Azerbaijan, Iran
[2] Student Research Center, Urmia University of Medical Science, Urmia, Iran

Abstract

Aim: The aim of the study is to estimate the diagnostic sensitivity and utility of high-resolution ultrasonography (HRUS) in comparison with a gold standard technique in the diagnosis of the nasal fracture.

Patients and Method: Using a retrospective study design, facial Computed Tomography (CT) and HRUS examinations were performed on 87 consecutive patients with nasal trauma. Ultrasonograms were obtained with a high frequency linear transducer (10 MHz). All patients also underwent facial conventional radiography (CR). The sensitivity and specificity for diagnosis of nasal fracture was evaluated for HRUS, CT and CR in comparison with the clinical examination. Then sensitivity and specificity of HRUS and CR were evaluated in comparison with CT.

Results: The sensitivity and specificity of HRUS, CT and CR in comparison with clinical exam in the diagnosis of nasal bone fracture was 97% and 100%, 86% and 87%, 72% and 73% respectively. The sensitivity and specificity of HRUS and CR in detecting fracture line in comparison with CT was 100% respectively 91%, and 79% respectively 95%.

Conclusion: HRUS is a reliable and available method for diagnosis of nasal bone fractures especially in the fracture, which is confined to the nasal bone and can be used as a modality of choice for investigation of nasal fracture.

Keywords: nasal bone, fracture, ultrasonography, computed tomography, radiography

Introduction

Nasal bone fracture is one of the most common fractures in patients with a maxillofacial injury [1]. It constitutes 39% of maxillofacial bone fractures and is more common in male than in female (2:1 ratio) [2,3]. Due to the high prevalence of nasal bone fracture in maxillofacial injury, the need for an accurate imaging modality to diagnosis such injuries is essential.

Previous reports show that radiographic investigations were negative in 25% of patients with nasal bone fractures who needed surgical treatment [4] and facial computed tomography (CT) evaluation of these patients carries a high risk of radiation to the lens. When comparing high resolution ultrasonography (HRUS) with CT and conventional radiography (CR), HRUS is a cheap, easily available, simple to perform, and has no risk of ionizing radiation to the lens. The diagnostic value of HRUS as a diagnostic modality in comparison with other radiographic investigation for diagnosis of nasal fractures lines has been shown in various studies [2,5,6].

Although physical examination (PHE) is the gold standard method for the diagnosis of nasal bone fracture, it cannot determine the complexity of the fracture [5]. To our best knowledge based on the review of previous literature there are very few studies that have compared ultrasonography with CT for the diagnosis of nasal fractures.

In this study we aim to evaluate CR, CT, and HRUS and compare the diagnostic value of each of them with the clinical diagnosis as diagnostic tools in the fractures of the nasal bone.

Received 09.09.2011 Accepted 09.10.2011
Med Ultrason
2011, Vol. 13, No 4, 292-295
Corresponding author: Mohammadi Afshin, MD,
Associate Professor of Radiology
Urmia University of Medical Sciences
Urmia, Iran
Mobile: +989143480425
Tel/fax: +98441_2353561
Email: mohamadi_afshin@yahoo.com

Material and methods

Between August 2009 and August 2011 we retrospectively evaluated all consecutive patients with a history of nasal trauma who were referred to our hospital for medical or legal consultation. All patients that underwent the three diagnostic methods (HRUS, CT and CR) were enrolled in the study. We collected clinical and imaging data of the patients from their clinical data sheet. After clinical examination (considered as the gold standard for the diagnosis of nasal bone fracture) the patients were investigated by CR at the first step and then, for confirming diagnosis, CT and HRUS were performed.

We excluded from the study all patients with nasal bone manipulation, closed or open reduction of fractures before referral to our hospital, and patients with more than 1 week interval between trauma and radiologic investigations.

All patients underwent the right and left lateral nasal view and Water's view (occipitomental view) of the nasal bones and all CR were interpreted by one experienced radiologist in head and neck imaging (fig 1).

CT examinations were performed with a multi–detector row CT device (Somatom Sensation 6; Siemens Medical Solutions, Erlangen, Germany) with 6 detectors. Axial and coronal scans were obtained separately with 3-mm-slice thickness on multi–detector row CT (fig 2). The interpretation of all CT scans was performed by another radiologist.

HRUS of the nasal bones was performed with a 10MHz linear transducer (Sonoline G 40, Siemens Medical Solutions, Erlangen, Germany). We divided the bony component of the nose into three parts: right and left nasal bone and dorsum (261 nasal components) and this division was used for diagnostic test calculation of HRUS and CR compared with CT. Ultrasonograms were obtained at these levels as: a midline longitudinal and axial image (fig 3); oblique longitudinal scans of the lateral walls of the nasal bone (fig 4). The transducer was applied directly to the skin without a standoff pad. A single radiologist (A.M) with 7 years experience performed all the ultrasonograms of the nasal bone.

Cortical disruption of the nasal bone in HRUS was considered the positive finding for fracture (fig 5). Soft tissue edema and subperiosteal hematoma was considered as a possible predictor in differentiating an acute from a chronic fracture.

Statistical analysis was performed using SPSS (version 16, Chicago, IL, USA) and R project (http://www.r-project.org/) to determine sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV). By incorporating both the sensitivity and specificity of the test to provide a direct estimate of how much a test result will change the odds of having a disease, the negative and positive likelihood ratios (LR- and LR+) were calculated. Computed tomography was used as the reference standard and 95% confidence interval were calculated.

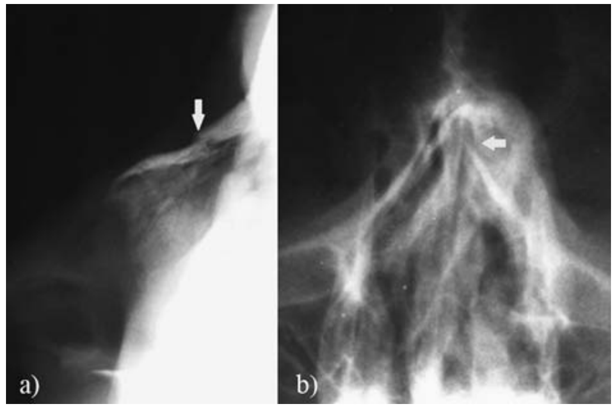

Fig 1. a) Conventional lateral nasal bone X-ray revealed a linear lucent fracture line (arrow). B) Occipitomental X-ray shows left nasal bone fracture and depression.

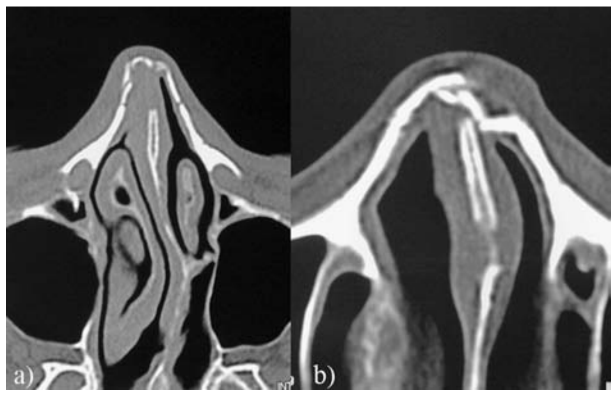

Fig 2. a) Axial CT scan shows lucent fracture line and displacement of the left nasal bone. B) Axial CT scan revealed left nasal bone and dorsum lucent fracture line and depression.

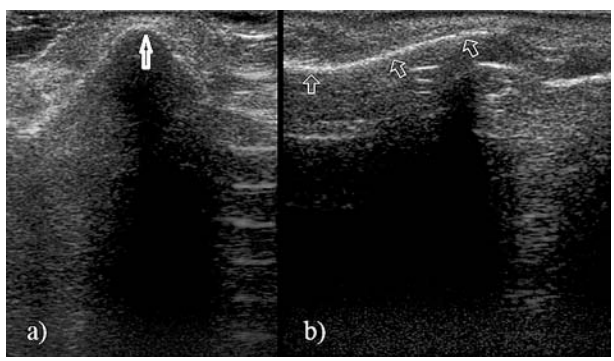

Fig 3. a) Axial ultrasonogram of dorsum shows intact cortical margin (arrow). B) Longitudinal ultrasonogram shows intact cortical margin as an echogenic line (arrows).

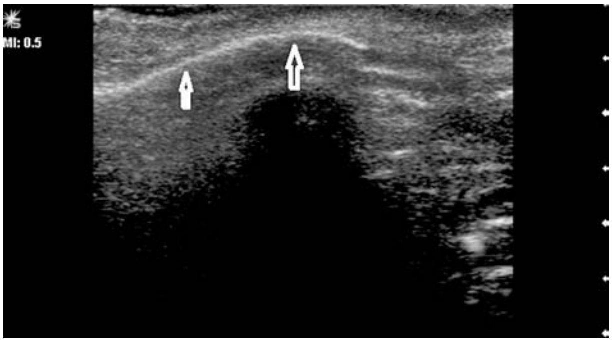

Fig 4. Oblique longitudinal ultrasonogram shows the normal appearance of the lateral wall of nasal bone as an echogenic line (arrows).

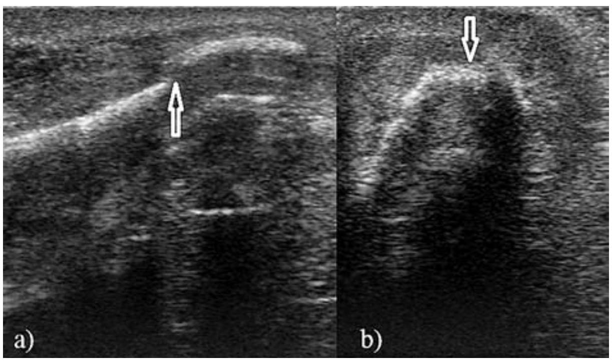

Fig 5. a) Longitudinal ultrasonogram shows a telescopic fracture of lateral wall of nasal bone. b) Axial ultrasonogram of dorsum revealed cortical disruption and depression of nasal dorsum with marked soft tissue edema.

Results

Eighty-seven consecutive patients were enrolled in the study (65 male and 22 female with a mean age of 27 years, range 17-60 years). PHE was positive in 72 and negative in 15 patients. The patients with negative PHE underwent radiologic studies due to legal issues. The most common causes of injury were human conflict (45%) and car accident (30%).

From 72 patients with positive PHE, HRUS detected fracture line in 70 patients, CT in 62 patients, and CR in 52 patients. The sensitivity and specificity of HRUS in comparison with PHE was 97% and 100% respectively. The positive likelihood ratio was 99 (95% CI: 2.02, 473), which represents a large and conclusive increase in the likelihood of a fracture in the presence of positive findings, and furthermore the negative likelihood ratio was 0.03 (95% CI: 0.01, 0.12) which proposed a large decrease in the likelihood of the fracture, in the presence of negative findings. The sensitivity and specificity of CT when compared with PHE was 86% and 87% respectively and positive likelihood ratio and negative likelihood ratios were 6.46 (95%CI: 1.77, 24) and 0.16 (95% CI: 0.09, 0.29) respectively. The sensitivity and specificity of CR in the diagnosis of nasal bone fracture when compared with the clinical exam was 72% and 73% respectively. The positive likelihood ratio and negative likelihood ratios were 2.71 (95% CI: 1.16, 6.35) and 0.38 (95% CI: 0.23, 0.61) respectively.

Twenty-one patients (24%) had concomitant facial bone fractures such as orbital wall or zygomatic bone that was diagnosed by CT. Most patients with a nasal bone fracture (55 patients- 76%) underwent close reduction and 8 underwent open reduction. Nine patients had no indication of undergoing surgery and were conservatively managed.

Among our patients with nasal bone fracture, subperiosteal hematoma and soft tissue edema was detected in 67 patients out of 72 cases with a clinically proven nasal fracture as an indicator of the acuteness of injury

The nasal pyramid divided into three parts (both lateral wall and dorsum) HRUS showed 105 fracture lines, CR revealed 71 fracture lines, and CT showed 90 fracture lines in the 261 nasal components. The sensitivity and specificity of HRUS in detecting the fracture line were 100% and 91% respectively and positive likelihood ratio and negative likelihood ratios were 11 (95% CI: 6.86, 18) and 0.0 (95% CI: 0.00, 0.10) respectively when compared with CT.

The sensitivity and specificity of CR in detecting the fracture line when compared with CT was 78% and 95% respectively and positive and negative likelihood ratios were 99.9 (95%CI: 17,42) and 0.22 (95% CI: 0.15,0.33) respectively (table I).

Table I. HRUS and CR accuracy compared with CT in nasal bone fractures' diagnosis

Diagnostic Accuracy Values	**HRUS**	**CR**
Sensitivity	100%	79%
Specificity	91%	95%
Positive Likelihood Ratio	11 (95% CI: 6.86, 18)	99.9 (95%CI: 17,4253)
Negative Likelihood Ratio	0.0 (95% CI: 0.00, 0.10)	0.22 (95% CI: 0.15,0.33)

Discussions

Nasal bone fracture has two peaks, the first between 15–25 years and the second after 60 years of age. Generally young people are more susceptible to fractures and displacement and the elderly develop comminuted fractures [2]. Almost 80% of nasal bone fractures occur between the middle third and the inferior part of the nose [7]. Due to possible legal matters accurate imaging of nasal fractures in many circumstances is critical.

For many years the standard imaging modality for the diagnosis of a nasal bone fracture was considered to be CR, until some reports showed a negative CR in 25% of patients with a nasal bone fracture who required surgical intervention [4]. Due to the low sensitivity of CR, its efficacy in clinical decision-making is controversial [8].

CT scan can precisely show anatomic details of the nasal bone and the soft tissue. It is also not operator dependent and can be easily interpreted by a clinician compared to other modalities. But it is not always sufficient because a fine nasal fracture line might be missed from the partial volume artifact effect [5]. A minor telescopic nasal fracture is more easily diagnosed on a CR than on a CT scan [5].

One report showed that HRUS can even show a disruption of 0.1 mm in the nasal bones [2]. So far only few studies have been conducted to evaluate HRUS for the diagnosis of a nasal bone fracture. In a study on 63 patients, Thiede et al found that the accuracy of sonography is greater than radiography in diagnosing the fracture line [6]. Hong et al found that the sensitivity of sonography in diagnosing nasal bone fracture is greater than radiography [5]. Danter et al reported a sensitivity of 83% and a specificity of 50% using a 20MHz sonography probe compared to PHE. He also showed that the sensitivity and specificity of sonography compared to radiography is 94% and 83%, respectively [9]. Zagolski et al showed that in individuals with a nasal bone fracture, the diagnosis can be made exclusively on the results of the sonographic examination [10]. Also our previous experience demonstrated a high accuracy of HRUS when compared with the CR evaluation of the nasal bone fracture [2].

We found subperiosteal hematoma and soft tissue edema in 67 patients out of 72 cases with a clinically proven nasal fracture as an indicator of the acuteness of injury. A previous study also showed that although with radiography it is not possible to differentiate between acute and chronic fracture lines, sonography can help by evidencing subperiosteal hematoma and soft tissue edema [2].

The other advantages of HRUS over CR is that, it can show trauma of the cartilaginous part of the nose more accurately [2,5] and also it is useful for intraoperative reduction of the fractured nasal bone [11,12].

One of the major limitations of HRUS in complex facial trauma is the detection of the other associated fractures of the facial bone. In this situation CT may be considered as supplementary to HRUS.

The main limitation of the study is the enrollment modality of the patients- only those patients who had underwent HRUS, CT and CR were included which may cause a selection bias. However, by including all consecutive patients this limitation was controlled.

In **conclusion**, HRUS is a reliable and available method for the diagnosis of nasal bone fractures especially in the fracture, which is confined to the nasal bone and can be used as the modality of choice for the investigation of a nasal fracture.

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