ISSN2515-8260 Volume 09,Issue 01,2022

An analytical cross-sectional study to evaluate the diagnostic accuracy of ultrasonography in detecting nasal bone fractures compared with CT as the reference standard

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Abstract

Aim: To evaluate the diagnostic accuracy of ultrasonography in detecting nasal bone fractures compared with CT as the reference standard.

Methodology: A cross-sectional study was conducted in the Department of Radiology, Maharshi Medical College & Hospital, Kumarhatti, Dist. Solan, Himachal Pradesh, pin code 173229 for the period of 1 year. The study group consisted of 100 patients with nasal bone fracture who were investigated by physical examination. These patients were then examined by conventional radiography and sonography. Physical examination was considered as the gold standard for the diagnosis of nasal bone fracture. All patients were investigated radiographically by a lateral and a Waters view X-ray at the beginning. The results were evaluated by a radiologist. The reports were then recorded as either "positive" or "negative" according to the existence of nasal bone fracture. Then, patients were examined by sonography. Soft tissue edema and subperiosteal hematoma was also examined as a possible predictor to differentiate an acute from a chronic fracture. The negative and positive likelihood ratios (LR- and LR+), NPV and PPV were calculated and used for determining the diagnostic accuracy. The LR-of ultrasonography was lower than radiography. The LR+of sonography for the diagnosis of nasal bone fracture was 65.20 [9.28-390.10] which represents a large and conclusive increase in the likelihood of the fracture in the presence of positive findings. Furthermore, LR of sonography was 0.14 [0.10-0.21] which proposed a large to moderate decrease in the likelihood of the fracture, in the presence of negative findings. LR+ of radiography was 6.20 [2.87-6.27] which showed a small increase of the likelihood of fracture in positive results and the LR^{-} of x-ray was 0.36 [0.21-0.42] which proposed a small decrease in the likelihood of the fractures when the findings were negative.

Results: In this study, 100 patients who had nasal bone fracture in their physical examination were investigated by sonography and radiography. Of these patients, 31 were women and 69 were men. The mean age of patients was 24.7 years. 37 (37%) patients were between 20-30 years and 28 (28%) were between 30-40 years, and 5 (5%) patients were < 20 years of age group, while 7 (7%) were > 50 yearsand 23 patients were between 40-50 years of age group. The youngest patient included in the study was a 12 year old male child and the oldest patientwas a male of 60 years of age. Of the 100 patients, 78 had nasal bone fracture (according to physical examination) and 22 patients were found normal but were investigated due to legal issues. Out of the 78 clinically proven nasal bone fracture cases, conventional radiography showed a fracture line in 65 cases.

Conclusion: Compared with the radiographic view, ultrasonography is a more adequate diagnostic tool for assessment of lateral nasal fractures. High-resolution ultrasonography can be used as an accurate technique for evaluating nasal bone fracture.

Keywords: Ultrasonography, nasal bone, fracture, radiographic view

Introduction

The nasal pyramid is a complex structure consisting of the 2 nasal bones and the 2 frontal processes of the maxillary bone. A nasal fracture can involve any part of the nasal pyramid. Nasal fractures are the most commonly observed fractures in the trauma setting [1].If there are no further injuries, such as hematomas or expanded fractures of the nasal septum, within 7 days after trauma the patient undergoes reduction of the nasal fracture under local anesthesia or, in cases of noncompliance, under general anesthesia. Afterward, the nose is fixed with a plaster cast. Some authors recommend nasal packs to stabilize the bone fragments, especially in the case of a depressed fracture [2].

Various imaging modalities are available, ranging from simple "plain film radiography," "ultrasonography" (USG), and "computed tomography" (CT). In the past, plain film radiography was the norm for diagnosing facial fractures. It has many disadvantages like lack of details in imaging complex facial bones, superimposition of overlying structures, image distortion, and unavailability of real-time imaging. These disadvantages can be readily alleviated by the use of CT, which is considered as a gold standard in imaging for maxillofacial fractures due to its enhanced clarity and details. CT is an essential tool for clinicians in diagnosing and visualizing maxillofacial fractures. It enables the diagnosis of undisplaced fractures, which are overlooked in plain film radiography. However, CT is known to have few disadvantages such as high radiation exposure, routine unavailability, high cost, distortion due to artifacts, and inability to provide real-time imaging [3].

USG is a safe, easy, and readily available imaging modality for soft tissues. Many advantages like low cost, easy availability, lack of ionizing radiation, and real-time imaging have made it an attractive low-cost, safer, and reliable imaging modality for diagnosing fractures of the maxillofacial region. A previous systematic review had recommended USG owing to its high sensitivity and specificity [3].

Early and accurate recognition and treatment of nasal trauma are important, because incorrect diagnosis and treatment can lead to later deformity [4]. Although clinical examinations are considered standard for diagnosing nasal fractures, hematoma and edema of adjacent tissues make it difficult to diagnose them [5]. Conventional radiography remains the standard imaging procedure, but water's view targeting the lateral nasal walls is prone to misinterpretation [6, 7]. Computed tomography (CT) is considered a gold standard for diagnosing complex facial fractures, especially mid-facial fractures [8-10]. However, CT is expensive, not readily available, and exposes the patient to high doses of penetrating radiation [5].

An alternative to radiography is ultrasonography, a common and easy method involving no additional radiation exposure. The value of ultrasonography (US) as a diagnostic tool for detecting fractures has been demonstrated [11, 12]. Recently, US has emerged as a useful diagnostic tool for acute nasal fractures, and has been described as an diagnostic alternative, with the advantages of being commonly available, easily used, and free of radiation exposure risks [12]. Higher frequency probes provide higher resolution of the nasal pyramid, especially of the nasal dorsum [13].

Materials and Methods

A cross-sectional study was conducted in the Department of Radiology, Maharshi Medical College & Hospital, Kumarhatti, Dist. Solan, Himachal Pradesh, pin code 173229 for the period of 1 year.

Methodology

The study group consisted of 100 patients with nasal bone fracture who were investigated by physical examination. These patients were then examined by conventional radiography and sonography. Physical examination was considered as the gold standard for the diagnosis of

ISSN2515-8260 Volume 09,Issue 01,2022

nasal bone fracture. All patients were investigated radiographically by a lateral and a Waters view X-ray at the beginning. The results were evaluated by a radiologist. The reports were then recorded as either "positive" or "negative" according to the existence of nasal bone fracture. Then, patients were examined by sonography.

The radiologists were informed of the primary diagnosis but they knew nothing about the physical examination and also of each other's diagnostic reports. Patients were examined in the supine position and in right, left and longitudinal views for evaluating the right and left side, the lateral wall and the dorsum of the nose. The positive criterion for sonographic observation was cortical disruption of the nasal pyramid. Soft tissue edema and subperiosteal hematoma was also examined as a possible predictor to differentiate an acute from a chronic fracture. The negative and positive likelihood ratios (LR- and LR+), NPV and PPV were calculated and used for determining the diagnostic accuracy.

Results

In this study, 100 patients who had nasal bone fracture in their physical examination were investigated by sonography and radiography. Of these patients, 31 were women and 69 were men. The mean age of patients was 24.7 years. 37 (37%) patients were between 20-30 years and 28 (28%) were between 30-40 years, and 5 (5%) patients were < 20 years of age group, while 7 (7%) were > 50 years, and 23 (23%) patients were between 40-50 years of age group. The youngest patient included in the study was a 12 year old male child and the oldest patient was a male of 60 years of age. Of the 100 patients, 78 had nasal bone fracture (according to physical examination) and 22 patients were found normal but were investigated due to legal issues. Out of the 78 clinically proven nasal bone fracture cases, conventional radiography showed a fracture line in 65 cases.

Table 1: Demographic details of the patients

Variables		N=100	%
Gender	Male	69	69
	Female	31	31
Age	Below20	5	5
	20-30	37	37
	30-40	28	28
	40-50	23	23
	Above50	7	7

Table 2: Comparative diagnostic values of Conventional X-ray and Ultrasonography

Diagnostic Accuracy Values	Ultrasonography [96%CI]	Conventional X-ray [96%CI]
Positive cases of Nasal fractures	65	78
Positive Likelihood Ratio (LR+)	65.20 [9.28–390.10]	6.20 [2.87-6.27]
Negative Likelihood Ratio(LR^-)	0.14 [0.10–0.21]	0.36 [0.21-0.42]
Positive Predictive Value(PPV)	0.94[0.90–0.96]	0.89[0.83-0.97]
Negative Predictive Value(NPV)	0.90[0.84–0.93]	0.73[0.66-0.84]

All 100 patients were examined by ultrasonography. The fracture line was shown in 65 out of 78 cases with a clinically diagnosed nasal bone fracture. Although physical examination results were positive for nasal bone fracture in 13 of the patients, the fracture line could not be found in ultrasonography. The LR-, LR+, PPVand NPV of ultrasonography were higher than radiography. The LR^- of ultrasonography was lower than radiography. The LR+ of sonography for the diagnosis of nasal bone fracture was 65.20 [9.28-390.10] which represents a large and conclusive increase in the likelihood of the fracture in the presence of positive findings. Furthermore, LR^- of sonography was 0.14 [0.10-0.21] which proposed a large to moderate decrease in the likelihood of the fracture, in the presence of negative findings. LR+

ISSN2515-8260 Volume 09,Issue 01,2022

of radiography was 6.20 [2.87-6.27] which showed a small increase of the likelihood of fracture in positive results and the LR^- of x-ray was 0.36 [0.21-0.42] which proposed a small decrease in the likelihood of the fractures when the findings were negative.

Discussion

Ultrasonography is a dynamic procedure that allows the reader to make the diagnosis from an unlimited number of pictures. This made it much easier for the 2 investigators performing the ultrasound examination to decide whether there was a nasal fracture than for the 2 readers whose decisions were based on 3 ultrasound images only. This suggests that results of an ultrasound examination are better when the procedure is performed by the same person reading the results.

In the study by Danter *et al*.[14], assessment of the nasal fracture yielded a sensitivity of 83% if the clinical diagnosis was used as the reference and a sensitivity of 94% if the radiography results were considered. These data are similar to the results reported in this study. Assessment based on ultrasound images yielded a sensitivity of 49% and a specificity of 69% with respect to the nasal bone. The analysis of the lateral nasal walls showed a sensitivity of 70% and a specificity of 70%. The final assessment of the nasal pyramid by ultrasonography reached a sensitivity of 77% and a specificity of 57%. These figures are lower than those reported by Kwon *et al*. [15], who located the nasal fracture in all patients using ultrasonography.

Because of the low Sensitivity of radiography, the diagnosis of nasal bone fracture is usually performed by physical examination[15].The Sensitivity of lateral and Waters radiographic view for the diagnosis of nasal bone fracture has been mentioned 75% in the previous studies[16].

In a study on 63 patients, Oliver *et al*., found that the accuracy of sonography is more than radiography in diagnosing the fracture line [16]. In another study carried out by Hyun *et al*., it was found that the Sensitivity of sonography in diagnosing nasal bone fracture is more than radiography [16]. In a study on 18 patients, Danter reported a Sensitivity of 83% and a Specificity of 50% using a 20-MHz sonography probe compared to physical examination. He also showed that the Se and Sp of sonography compared to radiography is 94% and 83%, respectively [19].

Zagolski and Strek showed that in individuals with nasal bone fracture the diagnosis can be made exclusively on the results of the sonographic examination [21]. In this study, we used a 10-MHz linear probe and the results of this study were similar to those from Beck *et al*., [20] who used a 5-7.5 MHz probe, and also were similar to the studies of Danter who used a 20MHz probe [18]. Sonography can show trauma of the cartilaginous part of the nose more accurately than radiography [16].

Conclusion

Compared with the radiographic view, ultrasonography is a more adequate diagnostic tool for assessment of lateral nasal fractures. High-resolution ultrasonography can be used as an accurate technique for evaluating nasal bone fracture.

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