Role of Ultrasonography and Conventional Radiography in the Detection of Fractures ;A comparative study

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Abstract:

Objective: With the collaboration of the trauma department, our study was designed to compare the effectiveness of ultrasonography and conventional radiography in the detection of bony fractures related to oral and maxillofacial regions.

Methodology: This comparative study was conducted from March 2020 to March 2021 at the Radiology department of Sarghoda medical college hospital with the collaboration of facial trauma department. Ultrasonography was performed by using GE- 730 Expert or a Philips IU22 USG machine along with a linear extraoral transducer (frequency range 7-15 MHZ). Patients were asked to sit in a seated position facing the sinologist. Transducers were placed over the site by applying the sterile gel.

Results: The overall sensitivity and specificity rate of ultrasonography was reported as 83.33% and 98.88% respectively in all sites whereas the sensitivity and specificity rate of conventional radiographs were reported as 70.24%, 100%. The negative predictive value of USG was reported as 96.17% along with 94.59% positive predictive value. In the contrast, conventional radiography gave a better positive predictive value (100%) than USG In our study we found better results of ultrasonography in terms of sensitivity and negative predictive value.

Conclusion: In conclusion, our study depicts that ultrasonography is an economical, useful diagnostic tool for examining the bony fractures of facial trauma with a better sensitivity rate when compared to conventional radiographs.

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Keywords:

Conventional radiographs, Bony fracture, Ultrasonography

Introduction:

Clinical diagnoses of facial injury are insufficient to examine the fracture lines which demand radiological assessment[1]. Conventional assessment of facial trauma involves a structural approach which includes history, palpation inspection, and auscultation[2]. Conventional radiographs play a key role in examining the location, magnitude, and displacement of fractures[3]. Nowadays the traditional method of conventional radiography is replaced with high imaging modalities including computed tomography and cone-beam CT (CBCT). However, these methods have some drawbacks in terms of expensive equipment, difficulty in maintaining a steady position, radiation exposure, and lack of availability in many regions of the world[1]. Hence, many physicians limit these methods and use ultrasonography in facial bony fractures. Ultrasonography is one of the best methods for the identification of pathology related to soft tissues present in the head and neck region[1]. In past, this method was widely used for detecting soft tissue lesions, salivary glands[2]. Very few studies reported its role in injuries related to maxillofacial[3]. Previous studies reported 85% accuracy of ultrasonography in detecting fractures related to zygomatic-orbital complex (ZMC)[1,4]. On contrary, another study reported the usefulness of ultrasonography in the visualization of the zygomatic arch and the frontal sinus anterior wall[5]. Ultrasonography failed to penetrate in deeper bony structure so its use is only restricted to examine the superficial facial fractures.

In many regions of midfacial fractures like orbit[6,7], nasal bone[8,9] and zygotic arch[10-12] ultrasonography reported successive outcomes. It also assists during surgery in examining the fracture reductions to attain adequate repositioning of fractured segments[13,14]. A systematic review conducted in 2011 reported the usefulness of ultrasonography in fractures related to the anterior maxillary wall in pregnant women and children without any radiation exposures[15]. With the collaboration of the trauma department, our study was designed to compare the effectiveness of ultrasonography and conventional radiography in the detection of bony fractures related to oral and maxillofacial regions.

Methodology:

This comparative study was conducted From March 2020 to March 2021 at the Radiology Department of Sarghoda medical college hospital with the collaboration of facial trauma department. The sample size of 277 sites was estimated by predicting 0.05% error with expected 90% sensitivity. However, in the final analysis, 20 patients were recruited for screening 440 sites (22 sites per patient). All the suspected patients of a facial skeleton who underwent CT scans and conventional radiographic examinations, visiting our facial and trauma center from March 2020 to March 2021 were included. To access the effectiveness of both techniques we set a time frame for inclusion because in delayed diagnosis many symptoms related to soft tissue resolved. Patients who were diagnosed during 0-15 days of trauma were only included.

Only conscious and cooperative patients during screening were included. Patients suffering from severe soft tissue lacerations, edema, and having complex fractures were excluded from the research. Patients with dressing and abrasions were also not included due to the probability of intense pain and discomfort. The study was carried out by following complete protocol for radiological assessment. Single examiner collected all the demographic details of patients including age, sex, occupation, trauma details including date and time of trauma, injury cause,

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Comment [YSAE8]: Please convert it to oedema and treatment after trauma. The same examiner conducted a clinical examination of each patient and recorded relevant findings of extraoral and intraoral examinations. Standard techniques of conventional radiographs were used for submentovertex view, water's view, and a panoramic view. Interpretation of the radiographs was done by two senior radiologists. On the other hand, a CT scan was performed by using 64 slice CT scanner and their interpretation was done by a single radiologist. We considered the results of CT as a gold standard for comparison with other techniques. Ultrasonography was performed by using GE- 730 Expert or a Philips IU22 USG machine along with a linear extraoral transducer (frequency range 7-15 MHZ). Patients were asked to sit in a seated position facing the sinologist. Transducers were placed over the site by applying the sterile gel. For this research, we define fracture as an interruption that occurs in the radiopaque line of the bony contour including displacement. The research was conducted by following all the principles of Helsinki. Written consents were taken from patients and they were well aware of the objectives and consequences of research[16].

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Statistical analysis was performed using SPSS 23.0. Frequencies were noted for all continuous variables. Sensitivity, specificity, negative and positive predictive values of USG and conventional radiographs were observed for comparison.

Results:

A total of 20 patients were recruited for this study. Out of these 20 patients, 18 were male with a mean age of 34.4 years (19-75 years). Traffic accidents were the major cause of injury in 90% of cases and 10% were reported due to falls from height. Approximately, 15-20 minutes per patient were consumed for examining all fracture sites using ultrasonography. During USG examination not a single patient reported discomfort or pain. For the conventional radiographs, approximately 20 minutes were taken for each radiograph. CT scan was performed in an average timeframe of 30-40 minutes for each patient. Each patient was bilaterally examined for 11 sites of the face. According to the standard protocol of CT scan, we examined 84 fractured sites. Out of these 84, fifty-nine sites were accurately detected by conventional radiographs whereas ultrasonography detected 74 sites. Out of these 74 sites we observed four false-positive results. Ultrasonography detected all the sites (mentioned in Table 1) accurately whereas conventional radiographs gave more accurate results for mandibular condyle/subcondyle sites. However, both methods failed to detect orbital floor fracture.

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The overall sensitivity and specificity rate of ultrasonography was reported as 83.33% and 98.88% respectively in all sites whereas the sensitivity and specificity rate of conventional radiographs were reported as 70.24%, 100%. The negative predictive value of USG was reported as 96.17% along with 94.59% positive predictive value. In the contrast, conventional radiography gave a better positive predictive value (100%) than USG In our study we found better results of ultrasonography in terms of sensitivity and negative predictive value (Table 2).

Examination Sites	USG (True Positive + False Positive)	Sensitivity of USG	Specificity of USG	Radiographs (True Positive + False Positive)	CT Scan Gold standard
Condyle/Subcondyle	4 (4+0)	80%	100%	5 (5+0)	5
Zygomatic Arch	12 (12+0)	100%	100%	12 (12+0)	12
Angle	2 (1+1)	100%	97.43%	1 (1+0)	1
Fronto-Zygomatic Process	3 (3+0)	33.33%	100%	0 (0+0)	9
Symphysis/ Parasymphysis	7 (7+0)	100%	100%	7 (7+0)	7
Zygomatic Bone	2 (2+0)	50%	100%	1 (1+0)	4
Orbital Floor	0 (0+0)	0%	100%	0 (0+0)	3
Anterior Wall of Frontal Sinus	4 (4+0)	100%	100%	0 (0+0)	4
Supraorbital Margin	5 (2+3)	100%	92.10%	2 (2+0)	2
Infraorbital Margin	19 (19+0)	100%	100%	17 (17+0)	19
Anterior/Lateral Wall of Maxillary Sinus	16 (16+0)	88.89%	100%	14 (14+0)	18

Table 1: Fracture distribution according to injury site[16]

Method	Gold Standard (CT scan)		Sensitivity	Specificity
	No fractures	Fractures		

Conventional radiographs	No fractures	356 (TN)	25 (FN)	70.24%	100%
	Fractures	0 (FP)	59 (TP)		
USG	No fractures	352 (TN)	14 (FN)	83.33%	98.8%
	Fractures	4 (FP)	70 (TP)		

Table 2: Comparison of sensitivity and specificity rates of conventional radiographs versus ultrasonography[16]

Discussion:

Face fractures occur at any site so the early detection of the site is effective time management. These fractures may occur alone or with a combination of several other injuries which may cause severe complications at a later stage. CT scan has some drawbacks in the form of high radiation and high probability of developing cataracts limit used in children and pregnant women[3]. Furthermore, CT scanning is a too expensive and time taking procedure in many parts of the world when used in isolated simple fractures[3]. These drawbacks laid the foundation for developing new and better imaging techniques which at least reduced these risks. On contrary, ultrasonography has many advantages in terms of cheap method, without radiation exposure, fast and high availability but demands experienced physicians to handle or interpret[5]. Ultrasonography can also reveal the various phases of fracture including healing. With these advantages, USG has privileged the other conventional radiography. However, ultrasonography can not deeply penetrate bony structures[5]. With this drawback, its use is currently limited to evaluating the superficial structures. Although, resolution can be increased still the deep penetration will not be acquired. In our study, we observed a total of 84 fractures sites out of 440 according to the gold standard of CT scan. In our study ultrasonography showed 83.33% sensitivity and 98.88% specificity of all fractured sites when compared to the CT scan. We observed 94.59% positive and 96.17% negative predictive value of ultrasonography. Comparing these results with other studies we did not find any study which contains all fractured sites. However, the sensitivity and specificity rates were similar to those studies which used ultrasonography for analyzing facial fractures. A study by Ayoub et al. reported an 85% accuracy rate of ultrasonography but their results vary at different sites in specificity, and positive predictive values[1]. When examining each site separately we found 100% sensitivity and specificity of ultrasonography for the anterior wall of the frontal sinus, parasymphysis, and zygomatic arc when compared to the conventional radiography. These results depict that no false positive or false negative values were present at these sites. Our results also depicted that ultrasonography is more reliable at the lateral wall of the maxillary sinus with 94% sensitivity and 100% specificity rate. At the anterior wall of the maxillary sinus, we observed 88.89% sensitivity and 100% specificity.

Out of 84 fracture sites we observed 14 false negative values of ultrasonography. Among these 14, six were fronto-zygomatic processes having 42.86% false value. Two of them were at the anterior/lateral wall of the maxillary sinus. Hence, at the fronto-zygomatic suture, we observed a 33.33% sensitivity of ultrasonography. We observed four false-positive values of ultrasonography of which the majority of them were located at the supraorbital margin with 92.10% at this site. The previous study of Jenkins[7] observed 86% sensitivity and 85% specificity of ultrasound for the diagnosis of orbital floor fracture. On contrary, our study failed to diagnose orbital floor fractures by using ultrasonography. We also observed that ultrasonography gave one false positive value at a mandibular angle and one false negative value at the mandibular condyle due to an undisplaced fracture of the neck. On contrary, 25 false negative values were observed in conventional radiographs. However, in our study, conventional radiographs reported zero false-positive value when compared to ultrasonography.

Conclusion:

In conclusion, our study depicts that ultrasonography is an economical, useful diagnostic tool for examining the bony fractures of facial trauma with a better sensitivity rate when compared to conventional radiographs.

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